Baseline water quality, soil, periphyton, and macrophyte data from Water Conservation Area 2A, 1998-1999.

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Introduction

In accordance with Everglades Forever Act and Consent Decree between the Federal and State of Florida governments, Water Conservation Area 2A (WCA-2A) will receive outflow from Stormwater Treatment Area 2 (STA-2), a filter marsh designed to remove nutrients from agricultural runoff before it is discharged into the area for the purpose of nutrient and hydropattern restoration. STA-2 is scheduled to begin operation in the year 2000. Ecosystem responses to this event will be documented as part of a long-term monitoring program implemented by the South Florida Water Management District (SFWMD) in accordance with the Army Corps of Engineers 404-Permit for STA construction and operation. Assessments of ecological benefits and impacts caused by STA discharge requires that baseline data be obtained as a basis for comparison. This report provides information on water quality, soil chemistry, and periphyton and macrophyte community structure and function in the receiving area during the period of March 1998 to present.

Monitoring Sites

In October 1997, three monitoring transects were established in northwestern WCA-2A, each running south from the L-6 levee towards the marsh interior. This orientation follows the anticipated direction of flow for discharges from STA-2. Wooden sampling platforms were constructed along each transect at distances approximately 0.25, 0.50, 1.0, 2.0, and 4.0 km away from proposed STA outflows (Figure 1). These stations are designated as $N_{0.25}$, $N_{0.50}$, $N_{1.0}$, $N_{2.0}$, $N_{4.0}$ (northern transect or "NTr"), $C_{0.25}$, $C_{0.50}$, $C_{1.0}$, $C_{2.0}$, $C_{4.0}$ (central transect or "CTr"), and $S_{0.25}$, $S_{0.50}$, $S_{1.0}$, $S_{2.0}$, $S_{4.0}$ (southern

Figure 1. Map of South Florida and the Everglades, including Water Conservation Area 2A (WCA-2A, darkened area), Stormwater Treatment Area 2 (STA-2), 404-Permit monitoring transects (NTr, CTr, STr) and stations (solid circles), and water control structures (open squares). Note: S-6 does not discharge into WCA-2A.

transect or "STr"). The 0.25, 0.50, and 1.0-km stations are referred to as "peripheral" stations (at the edge of the marsh near the levee) throughout this report. The 2.0 and 4.0-km stations are termed "interior" stations (closer to the marsh interior). The vegetation surrounding stations $N_{0.25}$, $N_{0.5}$, and $N_{1.0}$ is primarily dense cattail (*Typha domingensis,* Pers.). All other stations were located within dense to sparse sawgrass (*Cladium jamaicense*, Crantz.). Sampling was conducted directly from or in the immediate vicinity of the station platforms as diagramed in Appendix I.

Surface water

Methods

When sufficient surface water was present (> 10 cm), samples were collected monthly from the north (upstream) end of each platform (see Appendix I). Samples were preserved and shipped overnight on ice to the Florida Department of Environmental Protection (FDEP) for analysis of a number of water quality constituents (Table 1). All field and laboratory methods adhered to approved SFWMD and FDEP protocols (SFWMD, 1992; FDEP, 1997). At the time of collection, conductivity, dissolved oxygen, temperature, and pH were measured with a Hydrolab Minisonde™. The data presented in Figures 2-6 represent mean concentrations by station over the sampling period of March 1998 to January 1999. Where equipment blank samples had detectable concentrations of a constituent, data that were less than 3x the equipment-blank value were assumed to be contaminated and discarded. When equipment-blank concentrations were below detection limits, however, all data for that set of samples were used. After January 1999, no surface water could be obtained due to insufficient water in the marsh.

Sampling resumed in June 1999; however the results of these analyses have not yet been received.

Table 1. Surface-water and porewater constituents (* = constituent analyzed for surface-water only).

Constituent	Abbreviation	units
Water depth	Depth	m
dissolved oxygen	DO	mg/L
conductivity	COND	µhos/cm
pH	pH	pH units
alkalinity	ALK	mg/L
dissolved organic carbon	DOC	mg/L
total kjeldahl nitrogen (unfiltered)	TKN	mg/L
total dissolved kjeldahl nitrogen (filtered)	TKNF	mg/L
ammonium	NH_3	mg/L
nitrate+nitrite	NOx	mg/L
nitrite*	NO_2	mg/L
total phosphorus (unfiltered)	TP	mg/L
total dissolved phosphorus (filtered)	TPF	mg/L
soluble reactive phosphorus	PO_4	mg/L
total dissolved potassium	K	mg/L
total dissolved silica	SiO_2	mg/L
total dissolved iron	Fe	µg/L
total dissolved magnesium	Mg	mg/L
total dissolved zinc*	Zn	µg/L
total dissolved calcium	Ca	mg/L
total dissolved sodium	Na	mg/L
total dissolved copper*	Cu	mg/L
total dissolved chloride	Cl	mg/L
total dissolved sulfate	SO_4	mg/L

Results

Water depths fluctuated greatly but were generally very low throughout much of the sampling period as evidenced by negative (i.e. below ground) or zero mean values for all stations except $S_{4.0}$ (0.14 m) (Figure 2a). Chronologically, water levels declined during the summer months of 1998, then rose from September to November of 1998. A rapid decline again occurred from December 1998 to May 1999 after which water accumulated to the highest recorded depths in November 1999.

Surface-water pH was similar among stations within a range of 6.9 to 7.5 (Figure 2b). Mean DO concentrations were < 4.0 mg/L at the peripheral NT stations. However, DO increased to ~ 5 mg/L at NTr interior stations and ranged between 4.7 and 6.3 mg/L at CTr and STr stations (Figure 2c). Mean conductivity was 785 and 722 µhos/cm at $N_{0.5}$ and $N_{1.0}$, respectively, and declined to 395 µhos/cm at $N_{4.0}$. Conductivity readings along the CTr and STr were much lower, ranging between 216 and 437 µhos/cm (Figure 2d). Total suspended solids were generally undetectable (≤ 4 mg/L) with the exception of a few higher values at the peripheral NTr and STr stations (Figure 2e).

Alkalinity and concentrations of Cl, Ca, Mg, Na, and K were highest at peripheral NTr stations. With the exception of K, these constituents tended to decrease toward the marsh interior along the NTr but increased along the CTr and STr. Alkalinity ranged between 61.4 ($S_{0.25}$) and 216.3 mg/L ($N_{0.5}$) (Figure 3a). Concentrations of Cl ranged between 32.5 ($S_{1.0}$) and 123.7 mg/L ($N_{0.5}$) (Figure 3b). Ca varied slightly less with a minimum of 18.9 mg/L ($S_{0.25}$) and a maximum of 60.1 mg/L ($N_{0.5}$) (Figure 3c). Mg concentrations were lower, ranging between 5.2 ($S_{0.25}$) and 17.9 mg/L ($N_{0.5}$) (Figure 3d). Na showed a similar trend, with a range of 20.3 ($S_{0.25}$) to 83.2 mg/L ($N_{0.5}$) (Figure 3e). K

was much lower with a minimum concentration of 2.1 ($S_{4.0}$) and a maximum of 6.3 mg/L ($N_{0.25}$) (Figure 4a).

Highest concentrations of both Fe and Zn occurred at $N_{0.25}$. Fe varied from 21.0 to 84.5 µg/L (Figure 4b) while Zn ranged between 6.1 and 50.0 µg/L (Figure 4c). Cu was ≤ 0.2 (detection limit) at most stations although high concentrations of 3.5 and 3.1 µg/L occurred at $C_{0.25}$ and $S_{4.0}$ (Figure 4d).

Concentrations of DOC (Figure 4e), TKN (Figure 5a), and TKNF (Figure 5b) followed a trend that was similar to the major cations. Maximum concentrations of these constituents were found at peripheral NTr stations. By comparison, concentrations were much lower at peripheral CTr and STr stations, but increased slightly towards the interior stations along these transects. Specifically, ranges of DOC, TKN, and TKNF were 13.5 ($C_{2.0}$) - 35.2 mg/L ($N_{0.5}$), 0.6 ($C_{2.0}$) - 1.6 mg/L ($N_{1.0}$), and 0.7 ($C_{2.0}$) - 1.8 mg/L ($N_{0.5}$), respectively.

NH_3 was less than 0.10 mg/L at all stations with the exception of $N_{0.5}$, which was high (0.20 mg/L) due to a large increase in concentration in October 1998 (Figure 5c). NO_x was generally present at concentrations below 0.01 mg/L although higher levels (> 0.01 mg/L) were observed at the $S_{0.25}$ and $S_{0.5}$ stations (Figure 5d). NO_2 concentrations were at or below detection (≤ 0.004 mg/L) at all stations (Figure 5e). In contrast, PO_4 showed a well-defined gradient with the highest concentrations occurring at the *Typha*-dominated stations ($N_{0.25}$, $N_{0.5}$, and $N_{1.0}$). For example, PO_4 ranged between 0.028 ($N_{1.0}$) and 0.060 mg/L ($N_{0.25}$) at the peripheral NTr stations (Figure 6a) while the interior NTr stations both averaged ≤ 0.004 mg/L. Along the central transect, concentrations ranged between ≤ 0.004 ($C_{1.0}$, $C_{2.0}$, $C_{4.0}$) and 0.009 mg/L ($C_{0.5}$) and between ≤ 0.004 and 0.005

across all stations of the southern transect. TP and TPF exhibited a similar pattern with mean concentrations of both forms exceeding 0.080 mg/L at the $N_{0.25}$ station but less than 0.010 mg/L at $S_{4.0}$ (Figures 6b.c). More specifically, TP ranged between 0.006 ($N_{4.0}$) and 0.084 mg/L ($N_{0.25}$) along the NTr, ≤ 0.004 mg/L ($C_{2.0}$, $C_{4.0}$) and 0.016 mg/L ($C_{0.25}$) along the CTr, and ≤ 0.004 mg/L and 0.006 mg/L along the STr.

SiO_2 averaged between 8.3 ($S_{4.0}$) and 17.6 mg/L ($C_{0.5}$) among stations (Figure 6d) and SO_4 was present within a similar concentration range (Figure 6e).

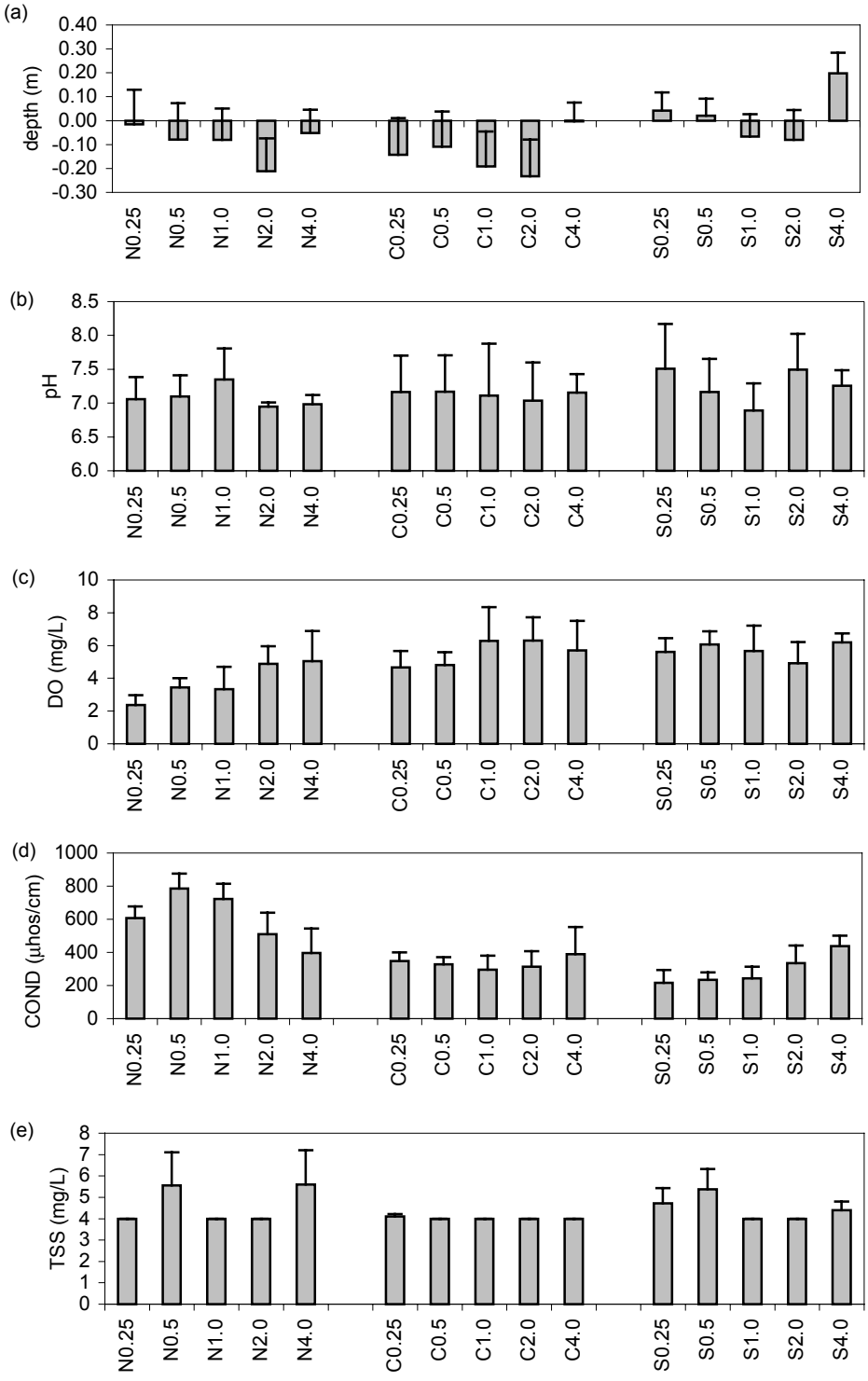

Figure 2. Surface-water characteristics by station (bars are means of all sampling dates + 1 standard error).

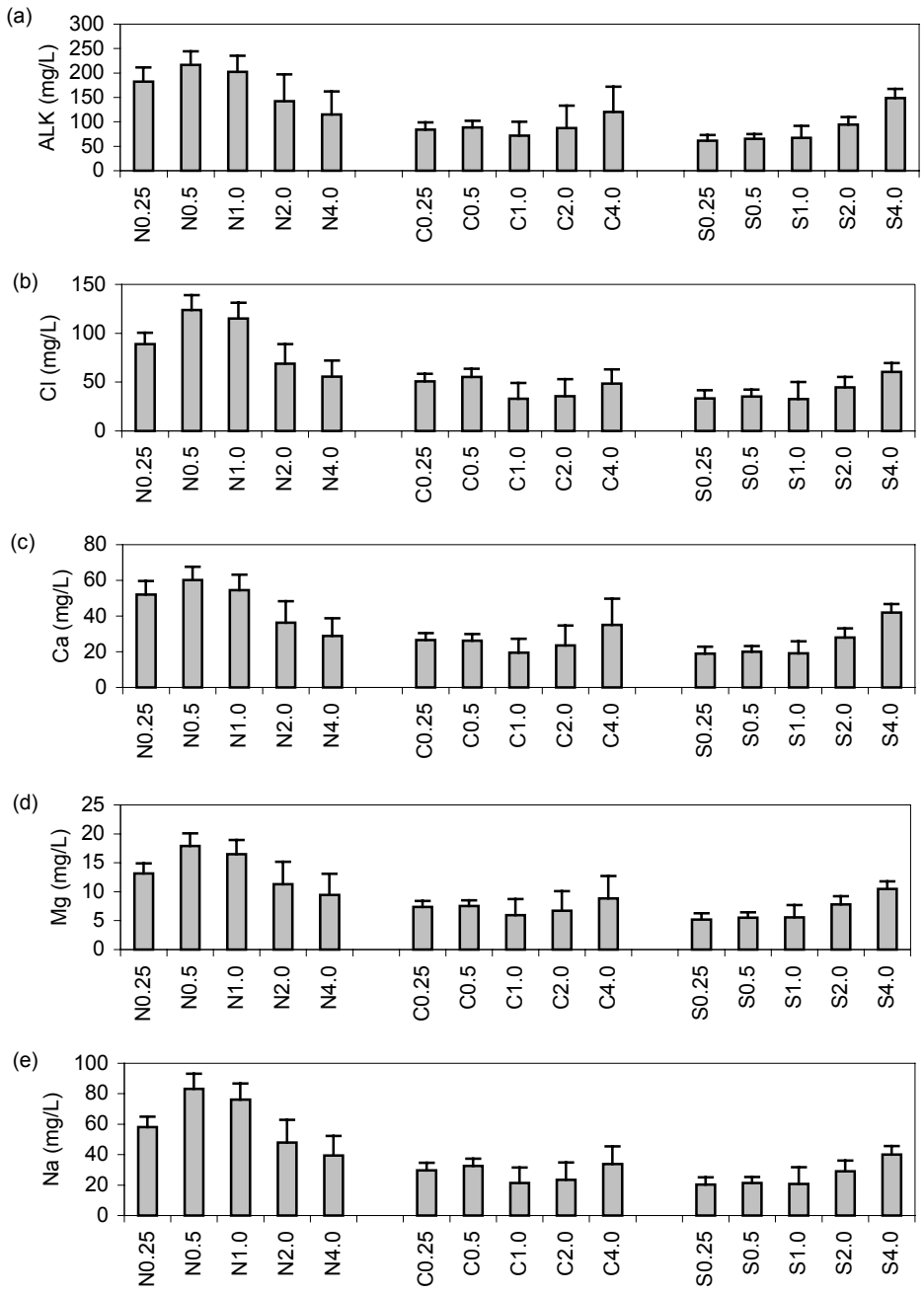

Figure 3. Concentrations of dissolved surface-water constituents by station (bars are means of all sampling dates + 1 standard error).

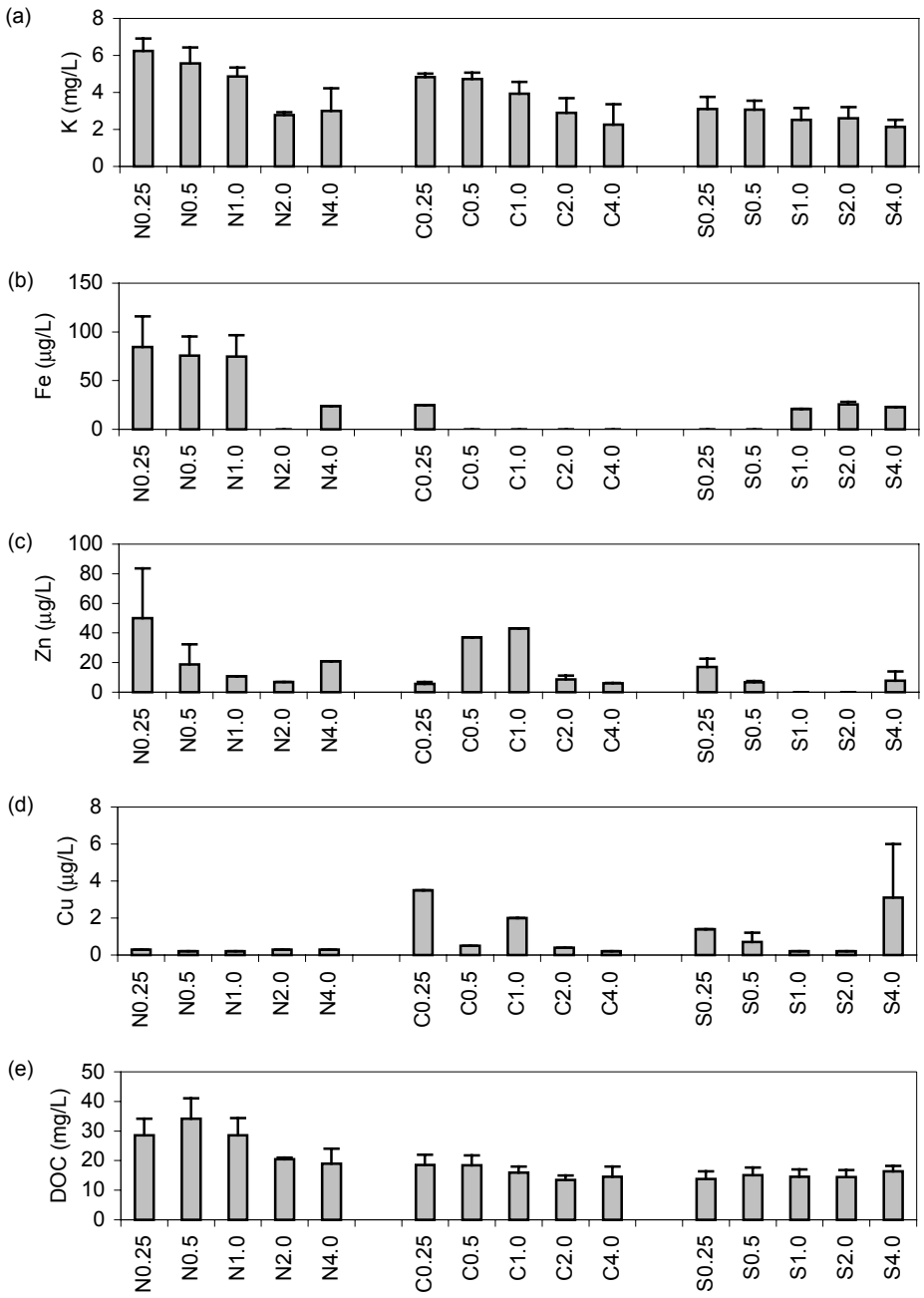

Figure 4. Concentrations of dissolved surface-water constituents by station (bars are means of all sampling dates + 1 standard error).

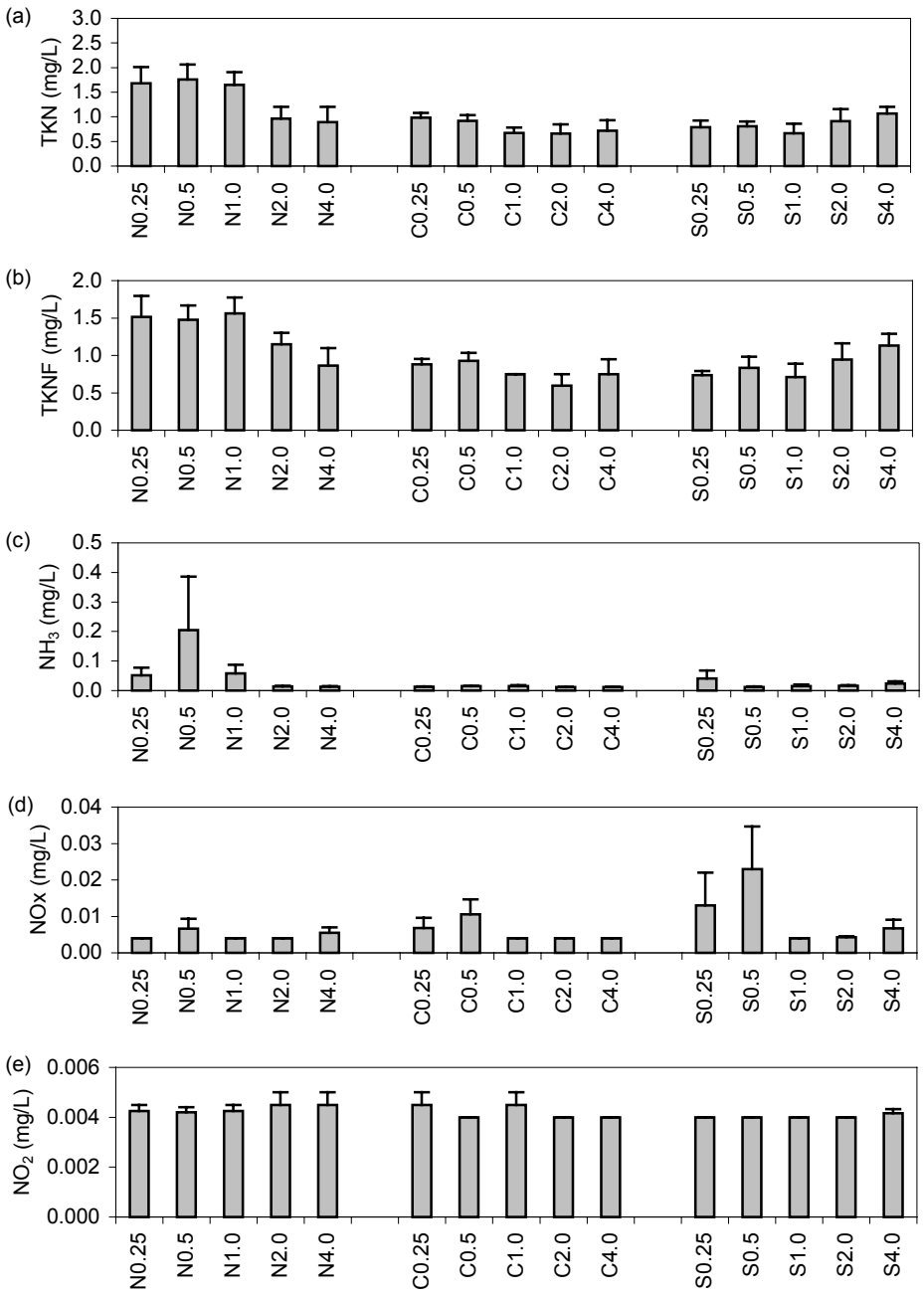

Figure 5. Concentrations of dissolved surface-water constituents by station (bars are means of all sampling dates + 1 standard error).

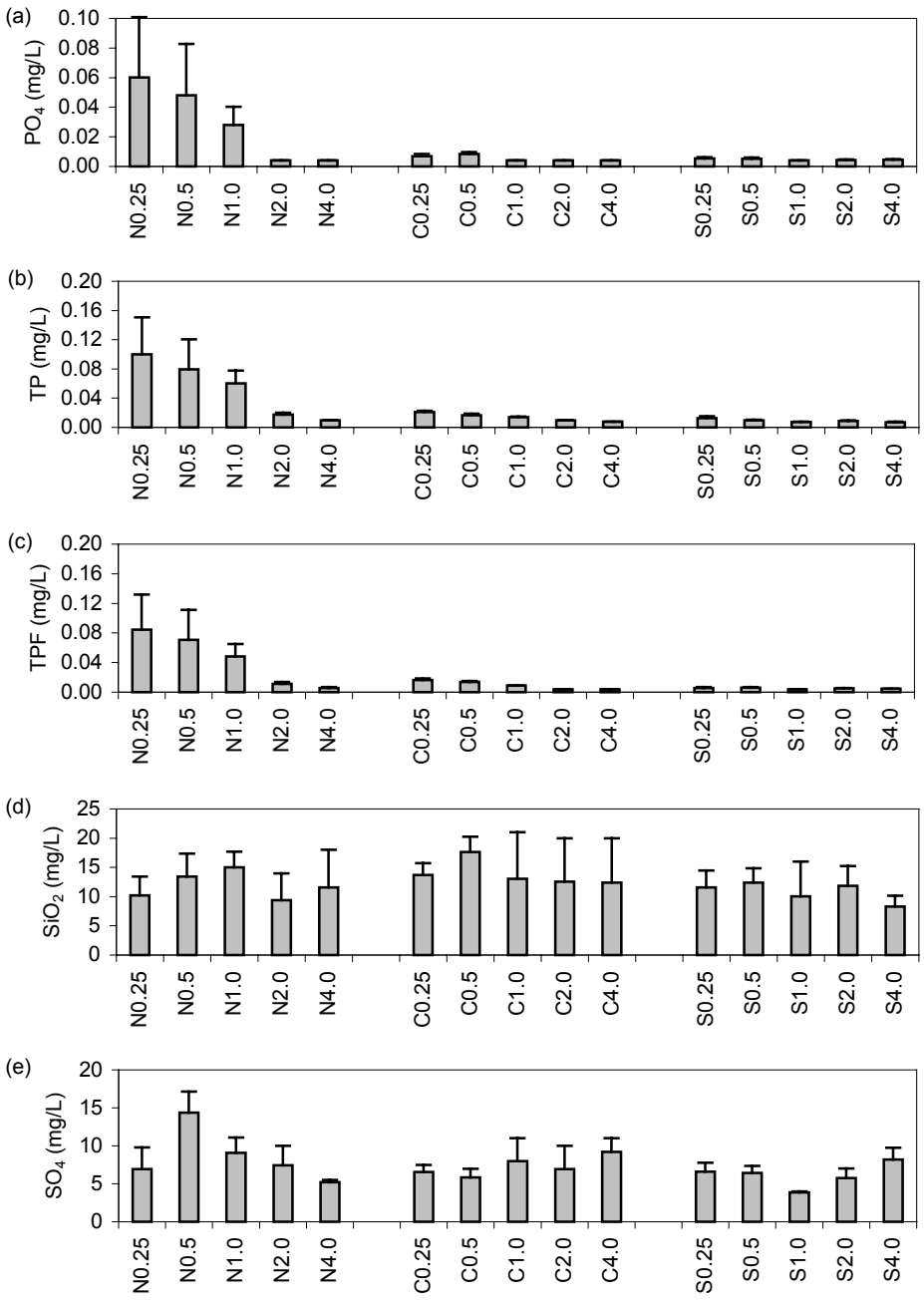

Figure 6. Concentrations of dissolved surface-water constituents by station (bars are means of all sampling dates + 1 standard error).

Porewater

Methods

A peristaltic pump was used to collect porewater from two 6-cm-diameter wells spaced approximately 1 m apart and located 1 m north of each platforms. Samples were collected and preserved according to SFWMD protocols (SFWMD, 1992) and sent to FDEP for analyses of selected water quality constituents (Table 1) by standard methods (FDEP, 1997). Although originally scheduled for collection on a quarterly basis, porewater sampling could only be performed in March and December of 1998 due to insufficient water at all other collection times. Sampling resumed on June 1999, but constituent analyses have not yet been completed.

Results

STr and CTr stations had slightly lower porewater pH values than NTr stations (Figure 7a). Mean pH ranged between 6.4 and 7.4 across all stations. Cl was highest along the NTr where, with the exception of $N_{0.5}$, all stations had mean concentrations exceeding 100 mg/L (Figure 7b). Concentrations along the CTr were generally lower (between 40.5 and 74.5 mg/L) but showed an increasing trend towards the interior ($C_{4.0}$). This pattern was more pronounced along the S transect where concentrations ranged between 30.2 and 84.5 mg/L. Ca and Mg exhibited a similar spatial pattern, with ranges of 18.6 ($S_{0.5}$) - 75.1 mg/kg ($N_{2.0}$) and 5 ($S_{0.5}$) - 23 mg/kg ($N_{2.0}$), respectively (Figure 7c,d). K concentrations varied slightly less, ranging between 2.1 ($S_{4.0}$) and 5.4 mg/L ($N_{0.25}$) across all stations (Figure 7e).

DOC showed a minimum of 13.5 mg/L at $C_{2.0}$ and a maximum of 34.2 mg/L at $N_{0.5}$. In general, DOC concentrations were slightly lower at peripheral compared to interior CTr and STr stations (Figure 8a). TKN concentrations were similar among stations (between 0.75 and 1.65 mg/L) with the exception of a high mean concentration of 3.35 mg/L at $S_{4.0}$ (Figure 8b). NH_3 also was high at the $S_{4.0}$ station with a concentration of 1.60 mg/L. Otherwise, concentrations were generally below 0.20 mg/L (Figure 8c). NO_x concentrations were all below 0.10 mg/L but varied considerably among stations (Figure 8d). Concentrations of TP (Figure 8e) and PO_4 (Figure 9a) were much higher at $N_{0.25}$ and $N_{1.0}$ than any other station. For example, TP was 0.047 and 0.064 mg/L at these stations while PO_4 was 0.028 and 0.47 mg/L. However TP ranged between ≤ 0.004 ($S_{4.0}$) and 0.021 mg/L ($C_{2.0}$) for all other stations. Likewise, PO_4 varied from a minimum of ≤ 0.004 ($N_{4.0}$) to a maximum of 0.013 mg/L ($C_{2.0}$).

Fe concentrations ranged between 17 ($S_{0.25}$) and 158 μg/L ($C_{0.25}$) and showed no well-defined spatial gradient (Figure 9b). S and SO_4 concentrations were highly variable among stations. Maximum and minimum S concentrations were 0.12 and 0.60 mg/L at stations $C_{2.0}$ and $N_{4.0}$ (Figures 9c,d). SO_4 ranged between 2.35 mg/L at $S_{2.0}$ and 10.22 mg/L at $N_{4.0}$.

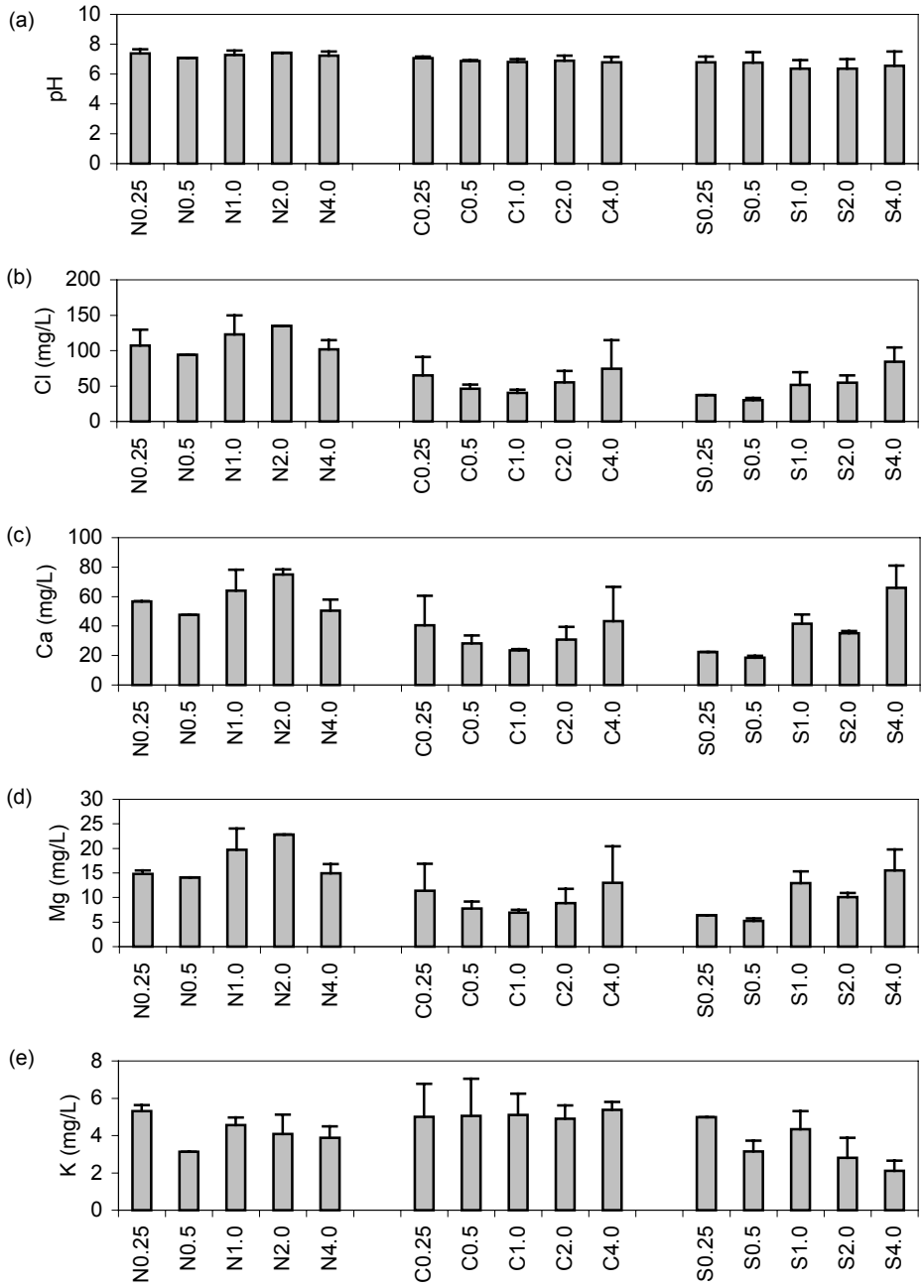

Figure 7. Porewater pH and concentrations of dissolved porewater constituents by station (bars are means of all sampling dates + 1 standard error).

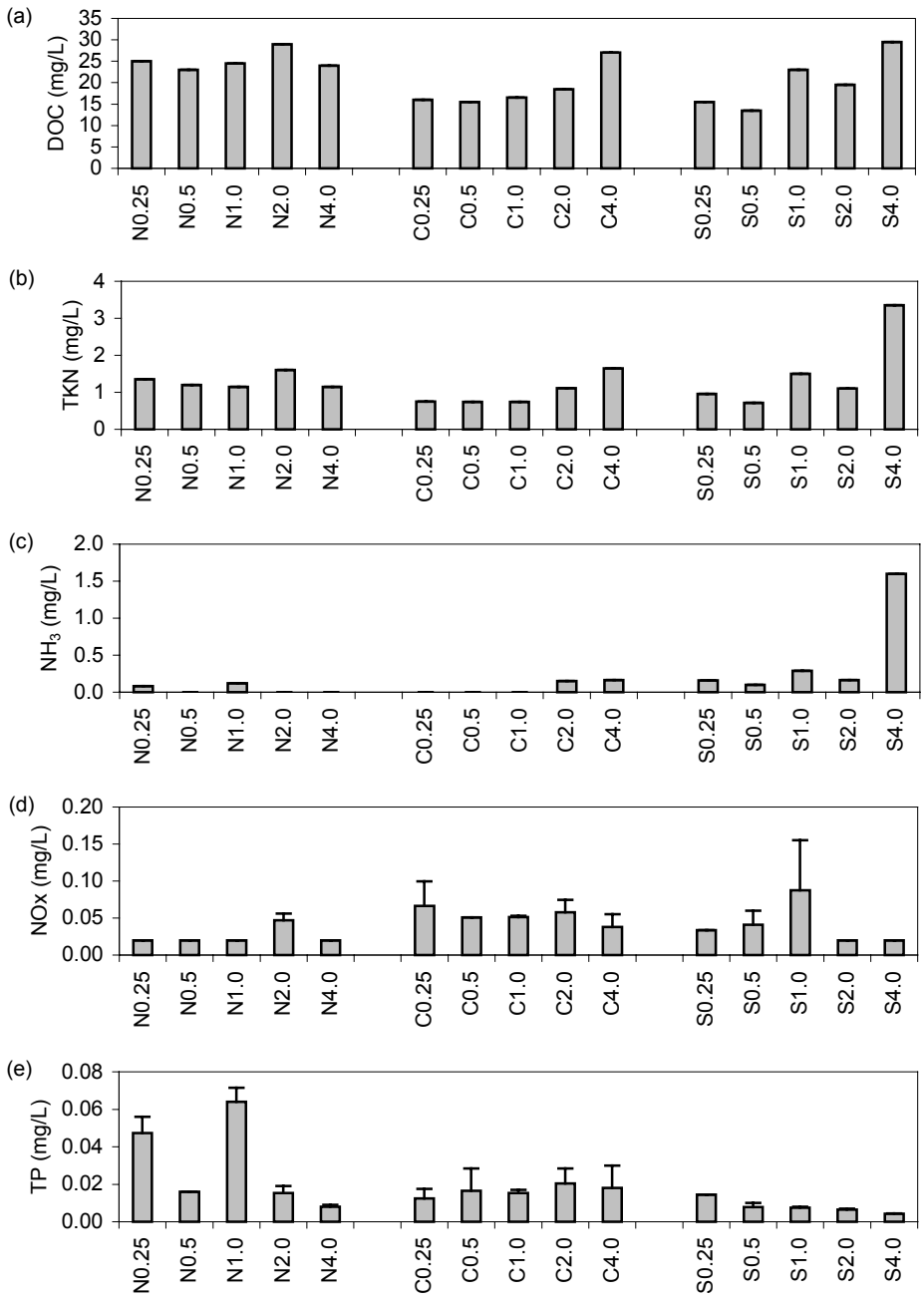

Figure 8. Concentrations of dissolved porewater constituents by station (bars are means of all sampling dates; error bars are + 1 standard error).

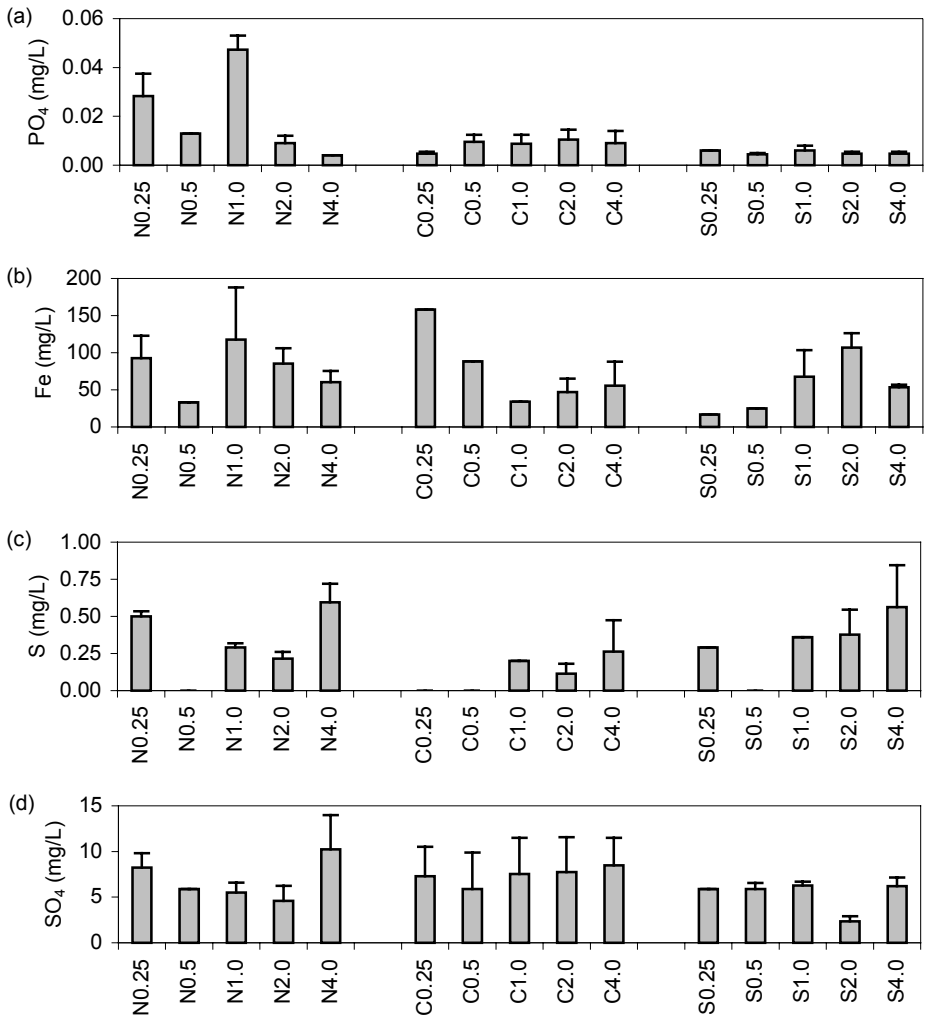

Figure 9. Concentrations of dissolved porewater constituents by station (bars are means of all sampling dates; error bars are + 1 standard error).

Hydrolabs

Methods

Precalibrated Hydrolabs™ were programmed to collect data for five days during October 1998 and for three days during October 1999. The Hydrolabs™ were suspended from tripods at selected stations (0.25, 1.0, and 4.0 km) of each transect. The tripods were placed within either *Typha*- ($N_{0.25}$, $N_{0.5}$, $N_{1.0}$) or *Cladium*- (all other stations except $S_{4.0}$). It was necessary to place each Hydrolab™ close to the sampling platforms so that the instruments could be reached without having to walk in the marsh and cause soil disturbance. As a result, the Hydrolab™ at $S_{4.0}$ was placed in an *Eleocharis*-dominated habitat that exists beside the station platform, even though the dominant vegetation of the area in general is *Cladium*. Each Hydrolab™ was positioned so that the probes hung at approximately mid-depth in the water column. Measurements of water temperature, dissolved oxygen, conductivity, and pH were collected every 30 minutes over the allotted time period. Temperature, conductivity, and pH data collected in October 1998 could not be used as declining water levels exposed the probes to air. The DO sensor, however, remained submersed and yielded reliable data.

Results

Dissolved oxygen - In October 1998, maximum (daytime) diel DO concentrations were very low (< 3 mg/L) at NTr stations and nighttime minima were frequently < 0.5 mg/L (Figure 10). CTr stations had slightly higher maximum and minimum concentrations. Concentrations at $S_{4.0}$ were considerably higher, with minima of ~ 3mg/L and maxima near 10 mg/L.

Fluctuations in diel DO concentrations at the NTr and CTr stations during October 1999 were much different than in 1998 (Table 2). In 1999, the NTr stations had DO maxima approaching 7 mg/L (Figure 11). Minima were < 1 mg/L at $N_{0.25}$ but > 1 mg/L at $N_{1.0}$ and $N_{4.0}$. The CTr and STr stations both exhibited a distinct gradient with respect to diel DO fluctuations. Peripheral stations had lower mean values and ranges than interior stations in 1999. For example, maximum and minimum diel DO concentrations at $C_{0.25}$ were ~ 6 mg/L and ~1 mg/L, respectively compared with concentrations of > 12 mg/L and ~ 6 mg/L at $C_{4.0}$. The differences between 1998 and 1999 data are likely a consequence of a fire that occurred in June 1999, which eliminated macrophyte biomass along the NTr and CTr. The STr did not burn and, accordingly, exhibited much lower diel variation. In addition, diel maxima and minima were very low at the $S_{0.25}$ and $S_{1.0}$ stations where dense *Cladium* was present. The $S_{4.0}$ station, which has a larger area of open water, had minima and maxima exceeding 3 and 7 mg/L, respectively.

Temperature - Diel surface-water temperatures showed some spatial variation with respect to means and ranges along the STr and, to a lesser extent, the CTr (Figure 12, Table 2). In this regard, the $C_{4.0}$ and $S_{4.0}$ stations exhibited wider diel fluctuations compared to the more narrow ranges at the $C_{0.25}$ and $S_{0.25}$ stations. Additionally, NTr and CTr maxima and minima were generally higher than those recorded at the STr stations. This variation is likely due to differences in light attenuation by macrophyte biomass, which was comparatively higher along the unburned STr and at peripheral stations compared to interior stations.

pH - Along the CTr and STr, pH means and ranges increased towards the marsh interior (Figure 13, Table 2). A range between 6.5 at station $S_{0.25}$ and 7.8 at station $C_{4.0}$

was recorded in October 1999. Along the NTr, however, diel pH maxima and minima were lowest at $N_{4.0}$ and highest at $N_{1.0}$. The highest diel variation along the NTr was observed at $N_{0.25}$.

Conductivity - Conductivity minima and maxima tended to increase towards the interior of each transect, with the trend becoming more pronounced along the STr (Figure 14, Table 2). For example, minimum diel conductivities ranged between 339 µhos/cm at $N_{0.25}$ to 413 µhos/cm at $N_{4.0}$. Maxima ranged between 349 and 444 µhos/cm for these stations. Ranges of CTr minima and maxima were 220 ($C_{0.25}$) to 319 µhos/cm ($C_{4.0}$) and 238 ($C_{0.25}$) to 339µhos/cm ($C_{4.0}$). Along the STr, conductivity at the $S_{4.0}$ station ranged between 273 and 322 µhos/cm. At $S_{4.0}$, however, conductivity ranged between 701 and 758 µhos/cm.

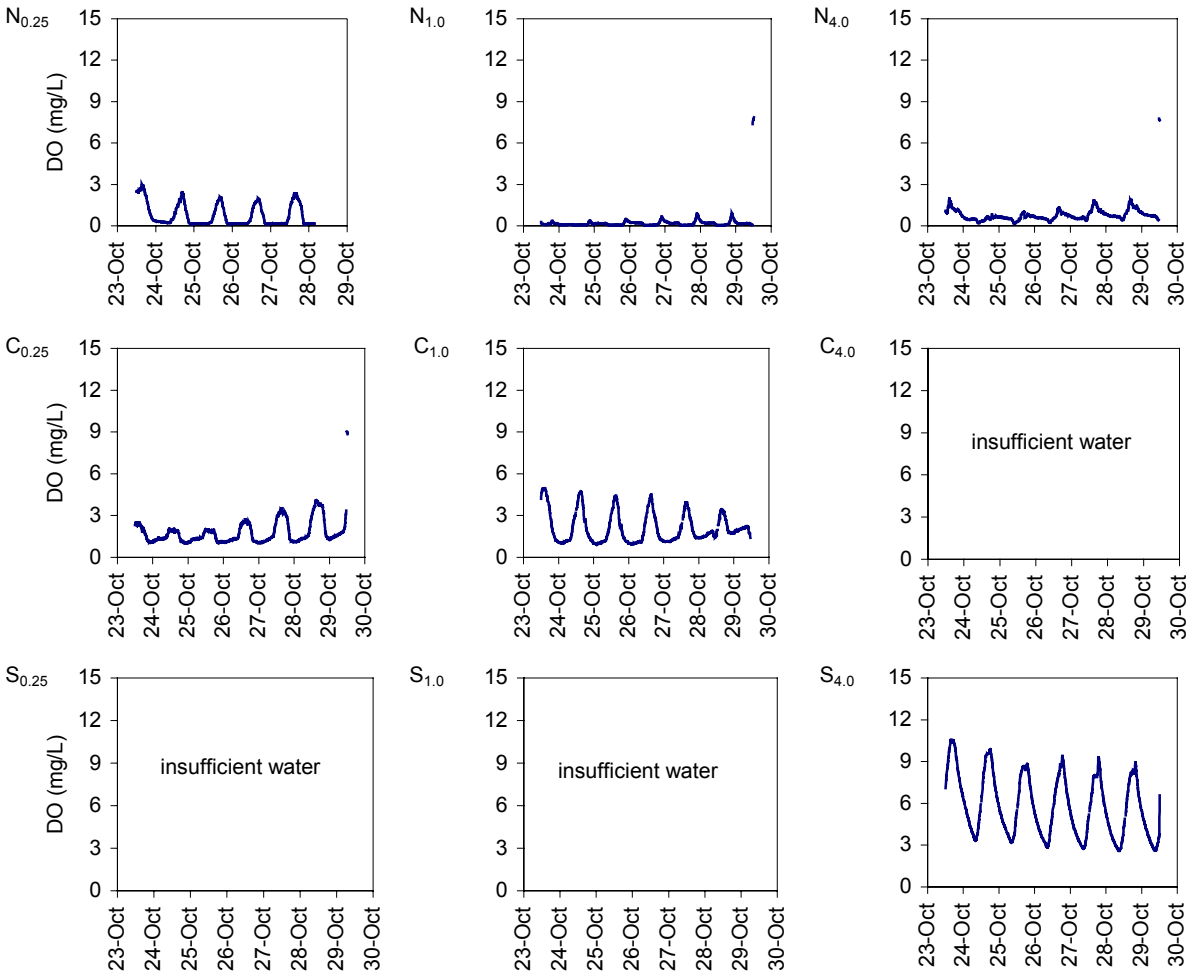

Figure 10. Diel dissolved oxygen concentrations by station for October 23-29, 1998.

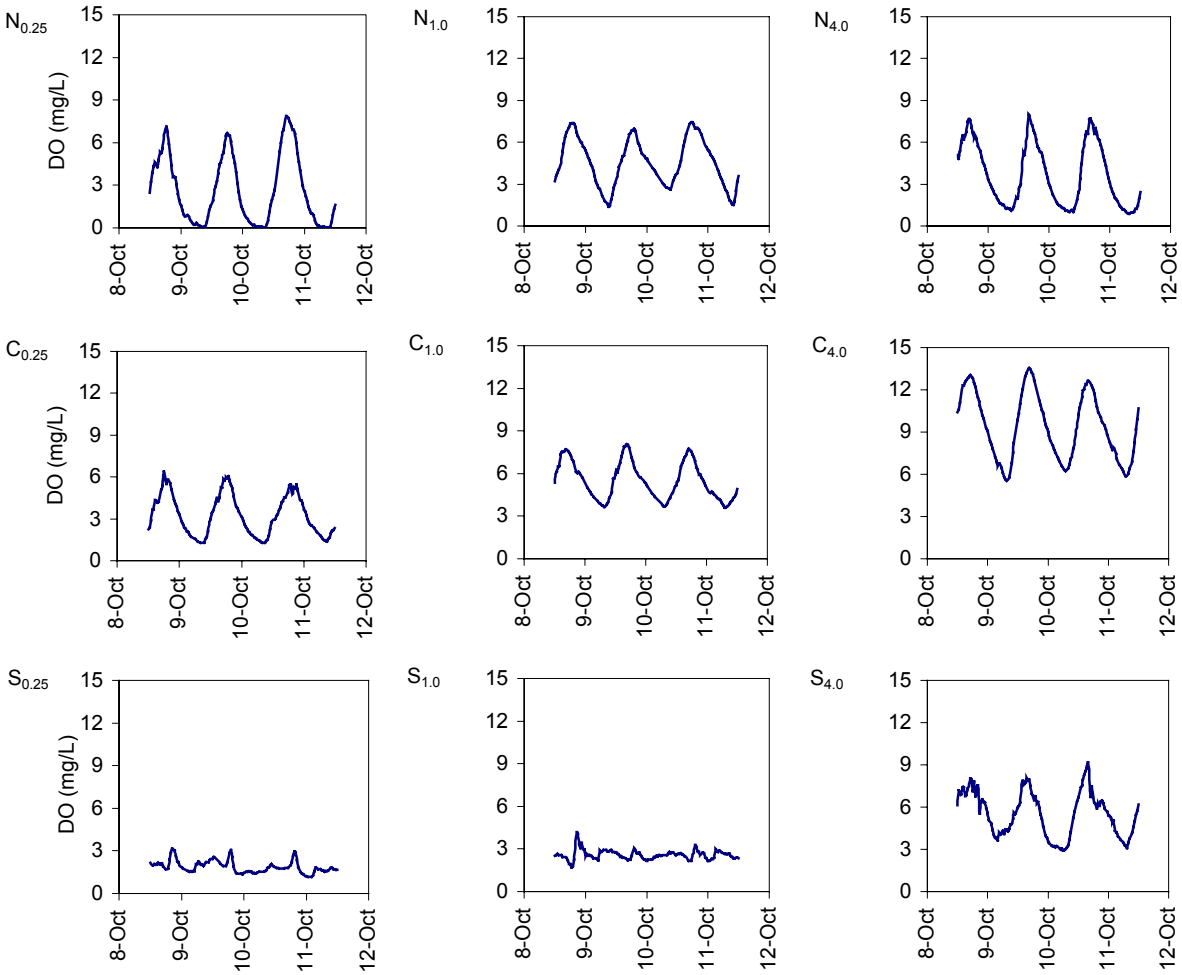

Figure 11. Diel dissolved oxygen concentrations by station for October 8-11, 1999.

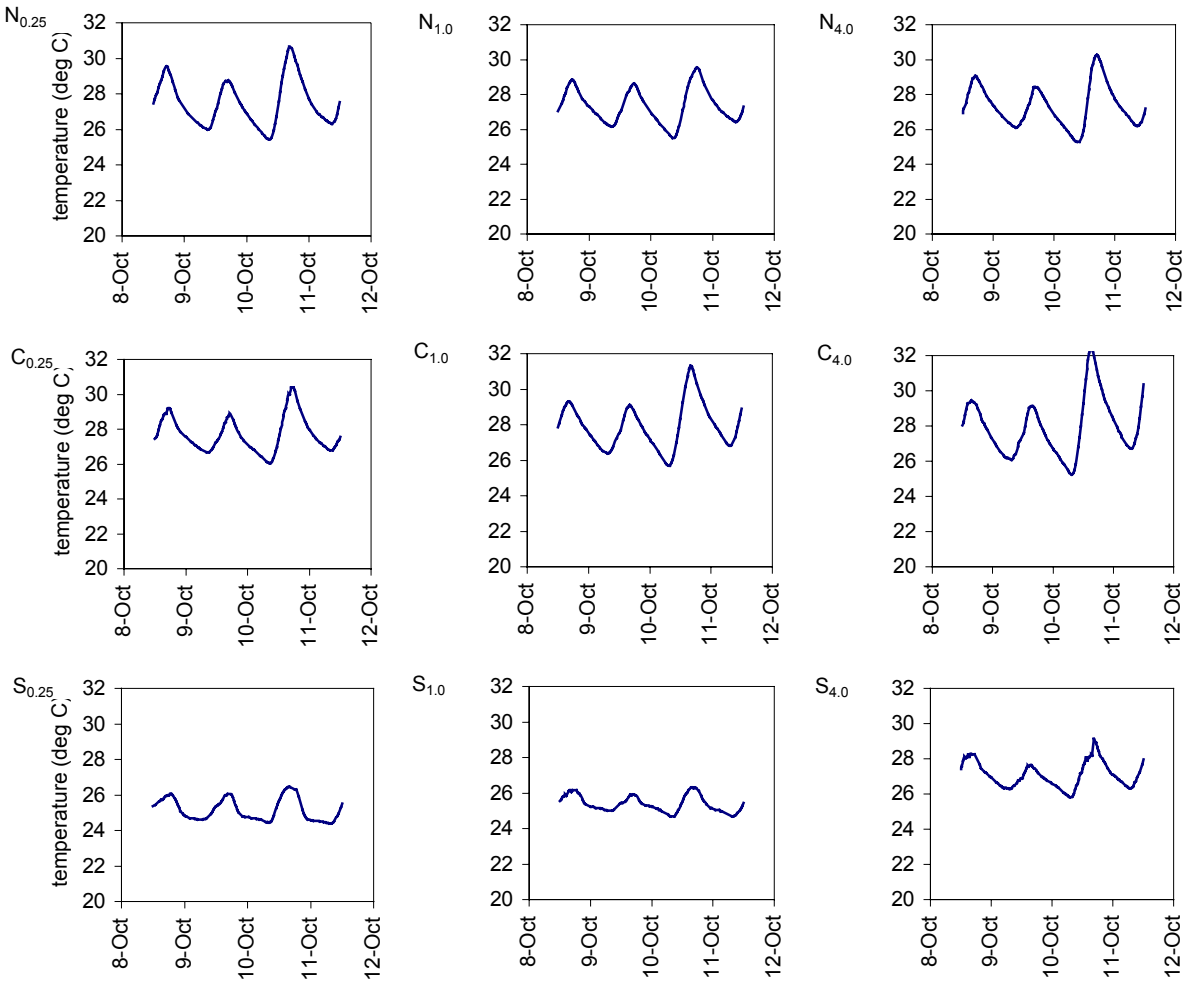

Figure 12. Diel temperature by station for October 8-11, 1999.

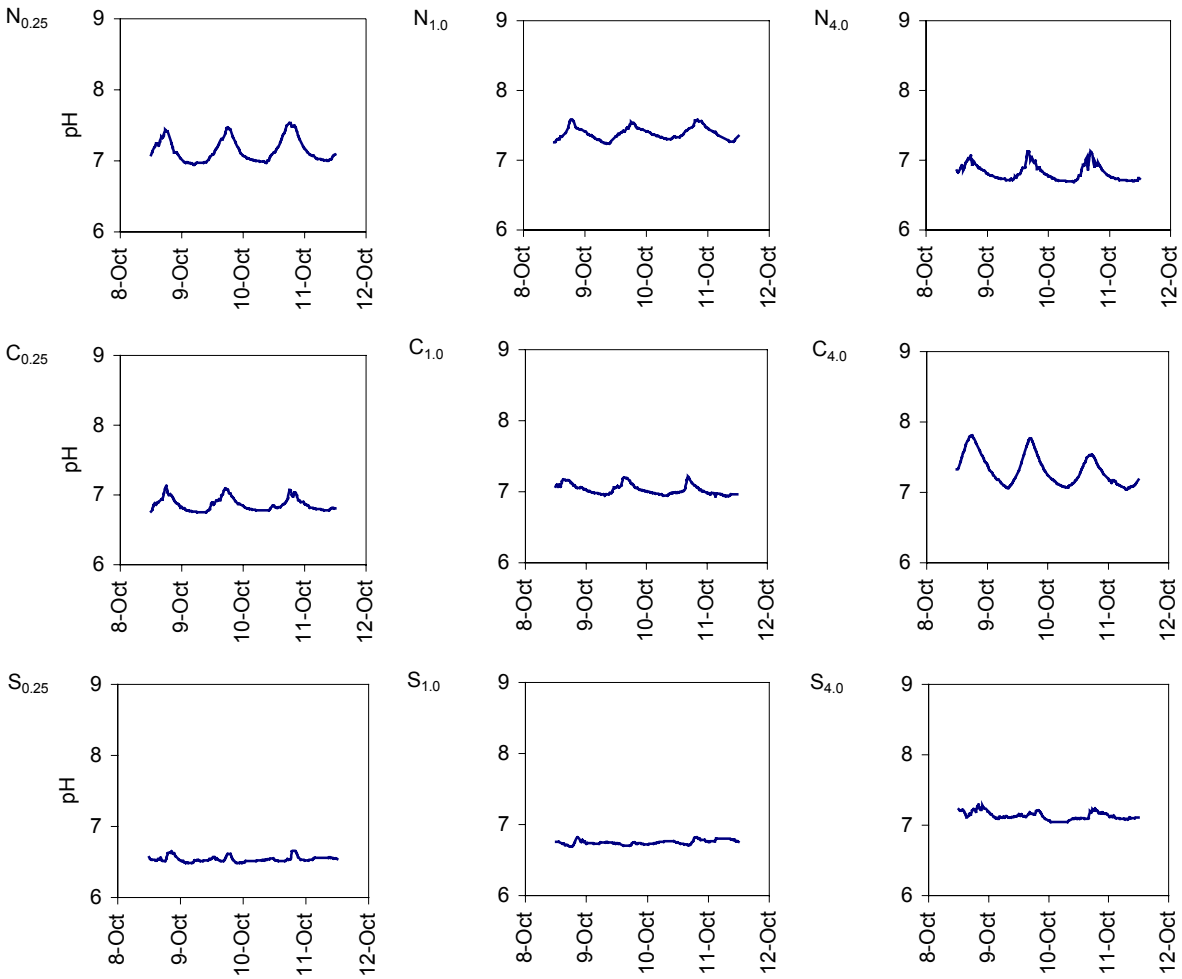

Figure 13. Diel pH by station for October 8-11, 1999.

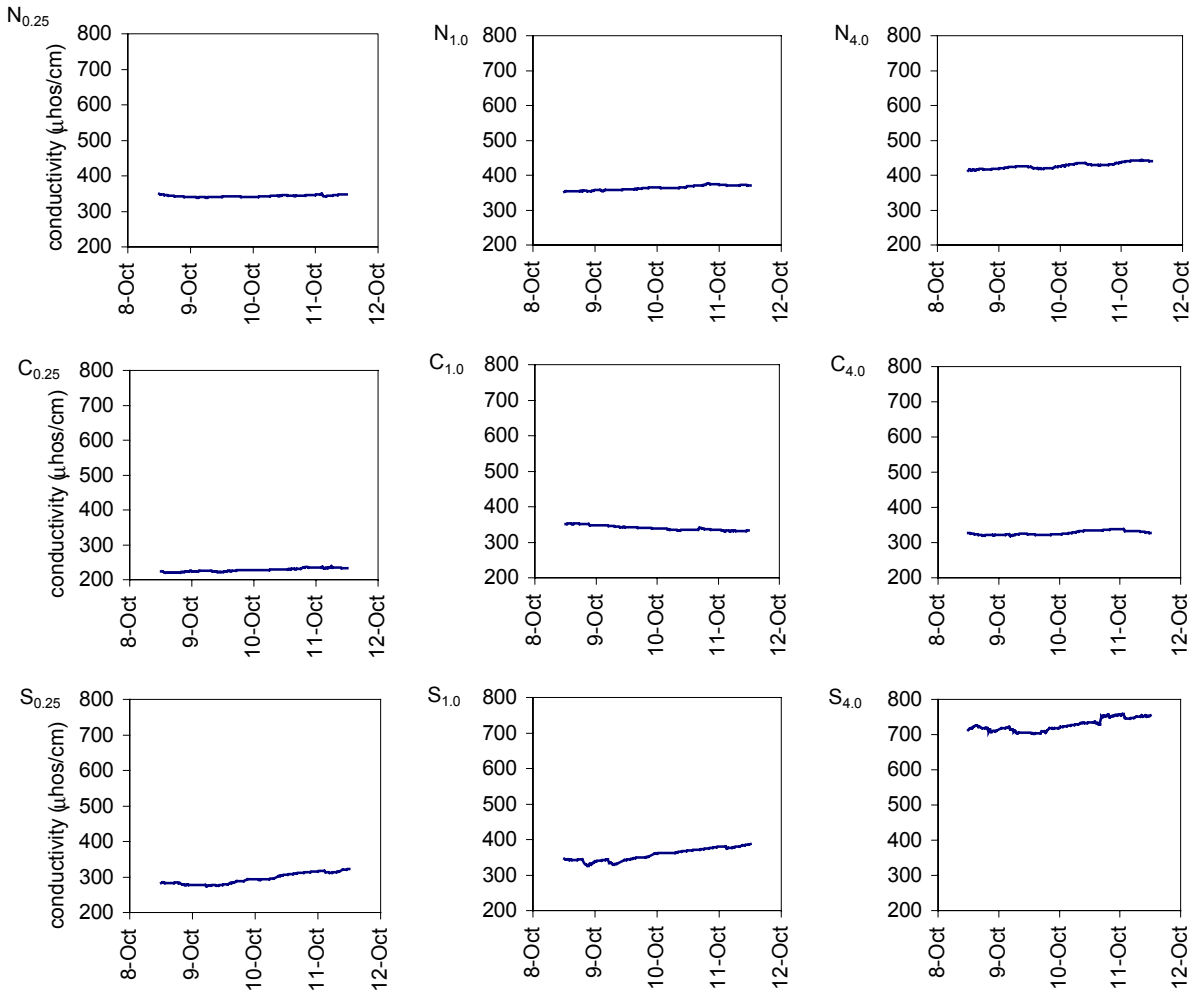

Figure 14. Diel conductivity by station for October 8-11, 1999.

Table 2. Maximum, minimum, and mean values by station for water quality parameters collected with Hydrolabs in October 1998 and 1999.

1998

	DO (mg/L)		
	max	min	mean
$N_{0.25}$	3.04	0.13	0.77
$N_{0.5}$	0.92	0.04	0.17
$N_{1.0}$	1.98	0.17	0.76
$C_{0.25}$	4.09	1.00	1.75
$C_{0.5}$	5.01	0.95	2.10
$S_{4.0}$	10.55	2.59	5.80

1999

	DO (mg/L)			Temp (C)		
	max	min	mean	max	min	mean
$N_{0.25}$	7.87	0.03	2.69	30.7	25.4	27.5
$N_{1.0}$	7.44	1.36	4.57	29.5	25.5	27.3
$N_{4.0}$	8.03	0.87	3.65	30.3	25.3	27.3
$C_{0.25}$	6.46	1.27	3.24	30.4	26.1	27.7
$C_{1.0}$	8.06	3.60	5.47	31.3	25.7	27.9
$C_{4.0}$	13.54	5.56	9.38	32.4	25.2	27.9
$S_{0.25}$	3.16	1.16	1.88	26.5	24.4	25.2
$S_{1.0}$	4.20	1.69	2.58	26.3	24.7	25.4
$S_{4.0}$	9.17	2.91	5.49	29.2	25.8	27.1

	pH			COND (µhos/cm)		
	max	min	mean	max	min	mean
$N_{0.25}$	7.53	6.95	7.15	349	339	343
$N_{1.0}$	7.58	7.24	7.39	376	353	364
$N_{4.0}$	7.13	6.69	6.82	444	413	428
$C_{0.25}$	7.13	6.75	6.86	238	220	228
$C_{1.0}$	7.22	6.94	7.03	353	331	340
$C_{4.0}$	7.81	7.05	7.32	339	319	328
$S_{0.25}$	6.66	6.49	6.54	322	273	295
$S_{1.0}$	6.82	6.69	6.75	387	326	358
$S_{4.0}$	7.29	7.05	7.13	758	701	727

Soils

Soil properties

Methods

Soils were sampled within the dominant vegetation type at each station, which was either *Typha domingensis* ($N_{0.25}$, $N_{0.5}$, $N_{1.0}$) or *Cladium jamaicense* (all other stations). A reference pole was placed within the vegetation at least 5 m to the east or west of each station platforms and triplicate samples were located by walking out approximately 2 to 3 m north, west, and south from these poles.

A 10-cm-diameter aluminum coring tube was placed on the soil surface, and a serrated knife was used to cut around its circumference in order to sever below-ground roots and thereby avoid soil compaction during core insertion. Cores were extruded and sectioned into 0-2, 2-10, and 10-20 cm depth layers. Samples were sealed in plastic bags, immediately placed on ice, and shipped overnight to an outside contract laboratory (DB Laboratories, Rockledge, FL). Soils were analyzed for bulk density, % ash, total carbon (TC), total nitrogen (TN), total phosphorus (TP), KCl-extractable inorganic phosphorus (readily-available P; KCl-SRP), HCl-extractable inorganic phosphorus (calcium- and magnesium-bound P; HCl-SRP), NaOH-extractable inorganic phosphorus (iron- and aluminum-bound P; NaOH-SRP), and NaOH-extractable total phosphorus (NaOH-TP). NaOH-extractable organic phosphorus (humic and fulvic acid-bound P; NaOH-Po) was then calculated as the difference between NaOH-TP and NaOH-SRP. The various analyses were done according to the procedures of ASA 1982, Page et al. (1982), USEPA (1983), USACOE (1986), and Reddy et al. (1991). Soils were collected in September

1998 and July 1999. However, the 1999 analyses are not yet complete and only the 1998 data is discussed here.

Results: *i) 0-2 cm layer* - Bulk densities in the 0-2 cm layer were < 0.20 g/cm^3 and declined along each transect towards the interior of the marsh (Figure 15a). Ash content ranged between 11 ($N_{0.5}$) and 20% ($N_{0.25}$) (Figure 15b). TC varied little with minimum and maximum concentrations of 427,333 ($N_{0.25}$) and 479,000 mg/kg ($C_{0.25}$), respectively (Figure 15c). TN also exhibited a narrow concentration range of 28,433 mg/kg ($S_{1.0}$) to 34,633 mg/kg at ($N_{0.5}$) (Figure 15d). By contrast, a clear gradient in TP existed, with the highest concentrations occurring at peripheral NTr stations and the lowest at interior STr stations (Figure 15e). For example, TP at $N_{0.5}$ was 1,212 mg/kg compared with only 534 mg/kg at $S_{4.0}$. KCl-SRP concentrations were extremely low, ranging between 5.1 ($N_{0.25}$) and 8.6 mg/kg ($N_{0.5}$) at peripheral NTr stations (Figure 16a). Soils from stations $C_{0.5}$ and $C_{2.0}$ also were high in KCl-SRP with concentrations of 7.0 and 7.3 mg/kg, respectively. In contrast, KCl-SRP in STr soils was < 3.0 mg/kg and declined from peripheral to interior stations. HCl-SRP concentrations were much higher than KCl-SRP and followed a gradient similar to TP, with a minimum concentration of 53 mg/kg at $S_{2.0}$ and a maximum concentration of 311 mg/kg at $N_{0.25}$ (Figure 16b). NaOH-SRP concentrations ranged between 25 ($S_{2.0}$) and 118 mg/kg ($N_{4.0}$). In general, NaOH-SRP increased toward the interior stations of each transect (Figure 16c). NaOH-Po showed somewhat less variation, ranging between 150 ($S_{1.0}$) and 270 mg/kg ($C_{0.25}$) across all stations except $S_{4.0}$, which had a much lower concentration of 54 mg/kg (Figure 16d). A similar pattern existed for NaOH-TP (Figure 16e).

2-10 cm layer - Bulk density, ash content, and concentrations of TC and TN differed little from the 0-2 cm layer. Bulk density ranged between 0.09 ($N_{4.0}$) and 0.19 g/cm^3 ($C_{0.5}$) (Figure 17a). Ash content was lowest at $N_{2.0}$ with a value of 12% and highest at $S_{4.0}$ with a value of 17% (Figure 17b). TC showed little variation with a minimum of 452,333 mg/kg at $N_{0.25}$ and a maximum of 528,667 mg/kg at $S_{1.0}$ (Figure 17c). TN also showed a limited range of 27,533 ($S_{4.0}$) to 35,967 mg/kg ($N_{0.25}$) (Figure 17d). TP, concentration in the 2-10 cm layer was lower compared with the 0-2 cm layer at all locations (Figure 17e). The general north-south/peripheral-interior TP concentration gradient observed in the 0-2 layer was much less pronounced, although still evident, with the highest TP concentrations of 577 ($N_{1.0}$) and 608 mg/kg ($N_{0.25}$) occurring at peripheral NTr stations. TP concentrations ranged between 328 ($C_{4.0}$) and 487 mg/kg ($C_{0.5}$) along the CTr and between 381 ($S_{4.0}$) and 501 mg/kg ($S_{0.5}$) along the STr.

Inorganic and organic P fractions were also much lower and less variable among stations compared to the 0-2 cm layer. The minimum KCl-SRP concentration of 0.7 mg/kg was found at $S_{4.0}$ while the maximum of 2.0 mg/kg occurred at $N_{0.5}$ (Figure 18a). HCl-SRP was higher and more variable, ranging between 22 ($C_{1.0}$) and 131 mg/kg ($C_{4.0}$) (Figure 18b). NaOH-SRP was lowest at $S_{0.25}$ with a concentration of 19 mg/kg and highest at $C_{4.0}$ with a concentration of 54 mg/kg (Figure 18c). NaOH-Po ranged between 82 ($N_{0.25}$) and 174 mg/kg ($S_{1.0}$) (Figure 18d) while NaOH-TP ranged between 108 ($N_{0.25}$) and 198 mg/kg ($S_{1.0}$) (Figure 18e)

10-20 cm layer (data not shown) - Bulk density and concentrations of TC and TN were similar to the 2-10 cm layer. Ash content also was similar (< 12%) in this layer except for samples collected from the $C_{0.5}$ station, where ash content was nearly 50% -- an indication that this area was burned in the past. Otherwise, ash content showed little spatial variation. TP and P fraction concentrations were much lower in the 10-20 cm layer compared with upper layers and showed no spatial gradient.

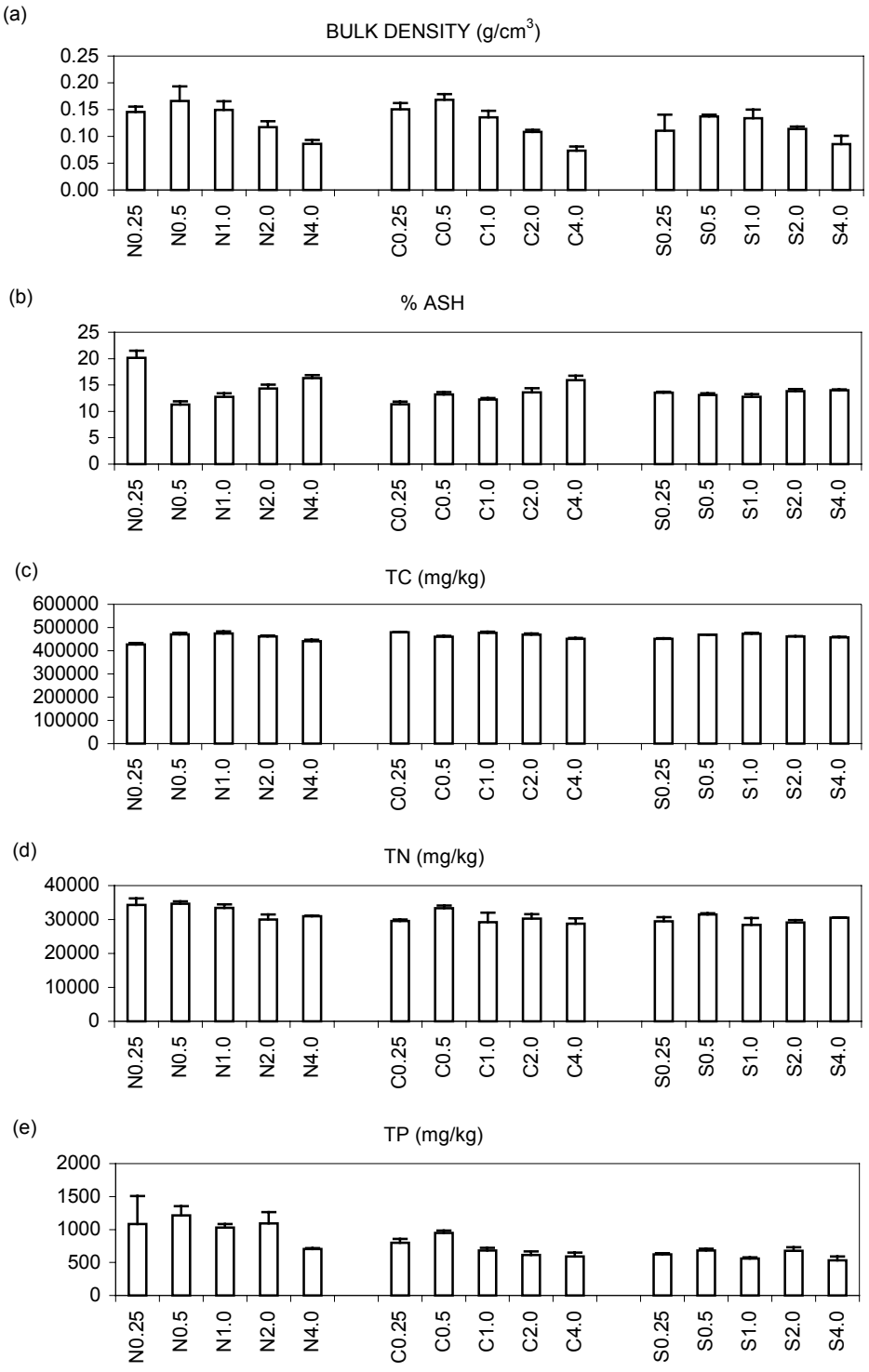

Figure 15. Bulk density, ash content, and nutrient concentrations (September 1998) in 0-2 cm soil layers by station (bars are means of triplicate samples +1 standard error).

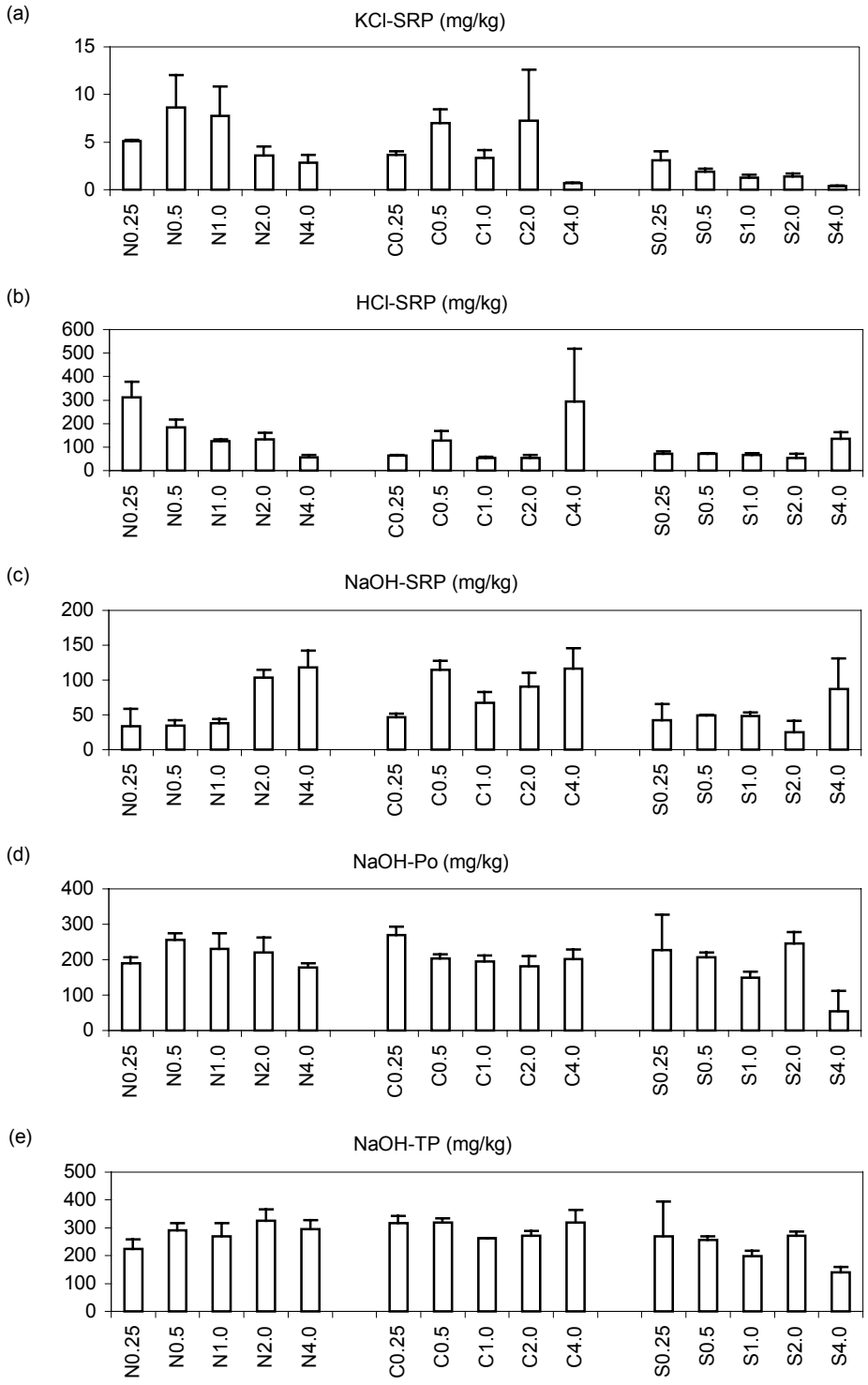

Figure 16. Concentrations of phosphorus fractions (September 1998) in 0-2 cm soil layers by station (bars are means of triplicate samples +1 standard error).

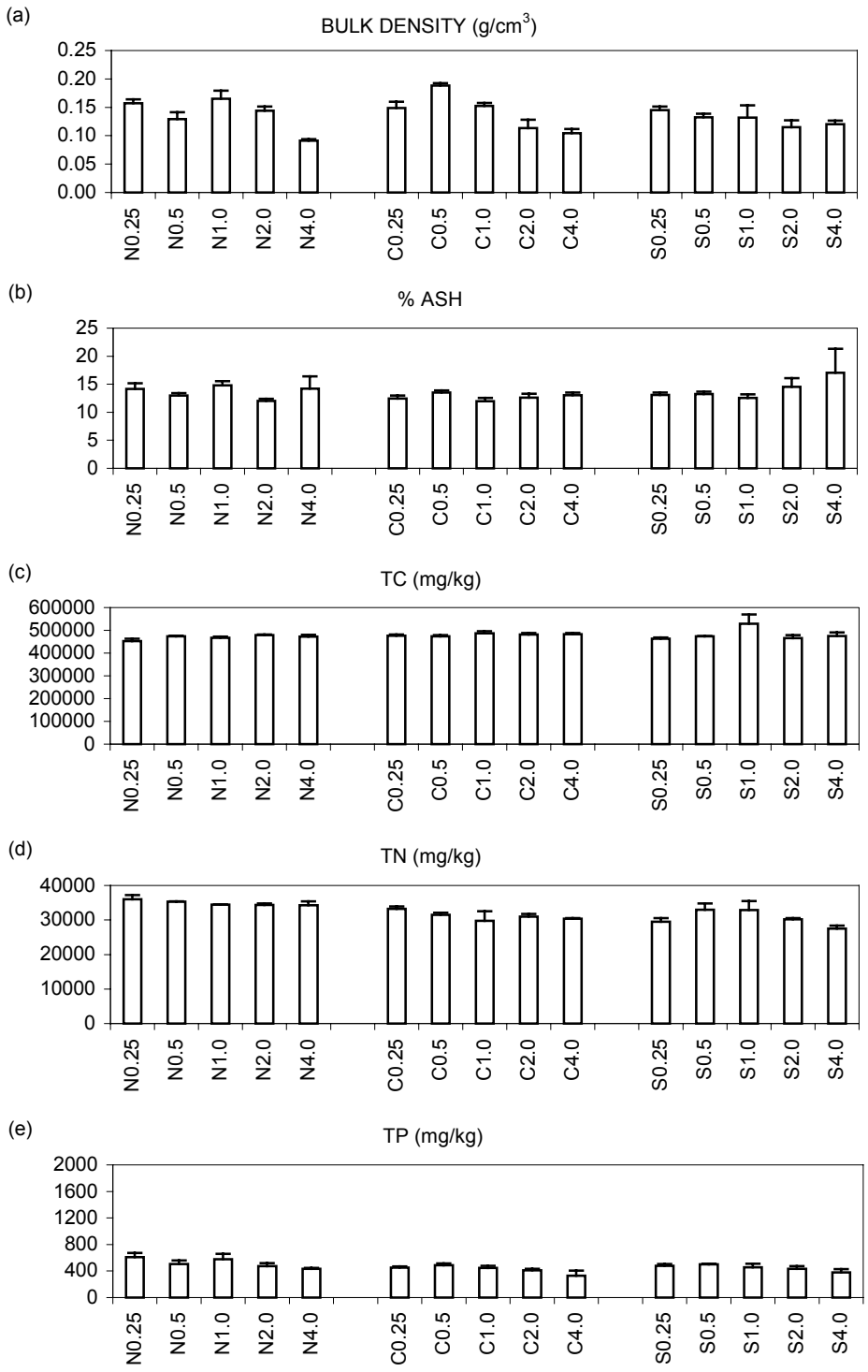

Figure 17. Bulk density, ash content, and nutrient concentrations (September 1998) in 2-10 cm soil layers by station (bars are means of triplicate samples +1 standard error).

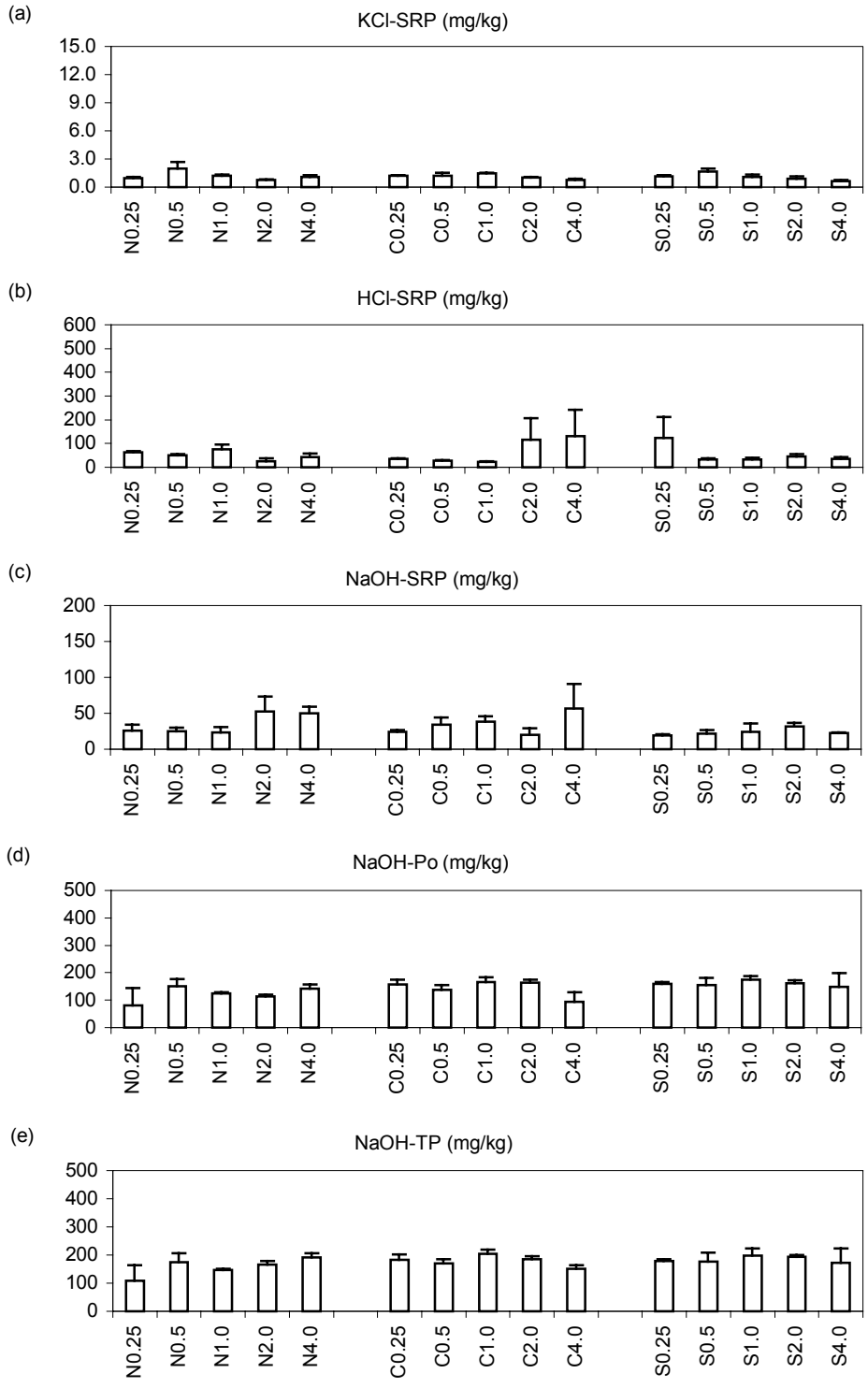

Figure 18. Concentrations of phosphorus fractions (September 1998) in 2-10 cm soil layers by station (bars are means of triplicate samples +1 standard error).

Soil accretion/erosion

Methods

In March 1998, three 0.25m^2 quadrats were inoculated with feldspar at stations $C_{0.25}$ and $C_{4.0}$ to mark the location of the sediment surface for soil accretion estimates. Soil accretion is measured as the thickness of soil accumulated above the feldspar layer. Although initial sampling of WCA-2A was conducted in December 1998, a fire that occurred in June 1999 destroyed the sites. The sites have since been reestablished (July 1999) but no data have been collected to date.

New Sedimentation Erosion Tables (SET), which measure soil subsidence, were recently installed at stations $C_{0.25}$ and $C_{4.0}$. Initial sampling of the sites will be conducted when water levels are low enough to facilitate data collection.

Periphyton

Due to long periods of low or non-existent surface water and dense macrophyte cover, periphyton is extremely sparse in this region of WCA-2A. Accordingly, very few samples could be obtained to characterize the periphyton community.

Biomass

Methods

Triplicate samples were collected by locating sites in the same manner as for soils (see Appendix I). Periphyton was harvested from within 0.25m^2 plots (delineated by a PVC frame) during May and October 1998 and August 1999. Free-floating periphyton (metaphyton) was collected and placed in a sealed plastic bag. All remaining underwater vegetation and associated periphyton (epiphyton) was removed by cutting at the soil-water interface and sealed in a separate plastic bag. Benthic periphyton (epipelon) was collected using a 10-cm diameter coring tube. Above- and below-water macrophyte biomass also was collected from the plots. Samples were placed in plastic bags, transported back to the laboratory on ice, and refrigerated until processed. Periphyton was manually separated from associated macrophyte material and then homogenized in deionized water. Quantitative subsamples were dried at 105°C for at least three days and then weighed. Dried material was ashed in a muffle furnace for one hour at 500°C and weighed to calculate ash-free dry mass (AFDM), which is the total amount of organic material (i.e., periphyton material) in the sample. Total AFDM for the sample was calculated based on the proportion of material processed and expressed on an areal basis

(g/m^2). Macrophyte biomass was dried for ~ 1 week at 80°C and weighed. All reported data are mean values of triplicate samples for each sampling station and date.

Results

Periphyton was present in such low amounts that no estimates could be obtained at most stations. Where it was present, biomass was highly variable among replicate plots, stations, and collection dates. In general, epiphyton was the dominant component of the periphyton community. Highest estimated values for epiphyton biomass in May 1998 were 65.1 g/m^2 and 43.1 g/m^2 at stations $N_{0.50}$ and $S_{4.0}$, respectively (Figure 18a). At $S_{4.0}$, epiphyton was significantly lower in October 1998 (0.8 g/m^2 AFDM) and August 1999 (2.4 g/m^2 AFDM) and below detection at $N_{0.5}$ on these dates. The $S_{4.0}$ station was the only site where significant amounts of metaphyton existed (Figure 18b). Metaphyon biomass at this station was 21.7 g/m^2 AFDM in May 1998 and 20.5 g/m^2 AFDM in October 1998. No metaphyton was found in August 1999 at $S_{4.0}$. Epipelon was below detection at all stations except $C_{4.0}$ and $S_{4.0}$ in October 1998 and $C_{4.0}$ in August 1999. Where present, epipelon biomass was quite low (< 5 g/m^2 AFDM) (Figure 18c). Total periphyton biomass appeared to be at least partly related to light availability as the highest amounts were found where above-water macrophyte biomass was low (Figures 18d,e).

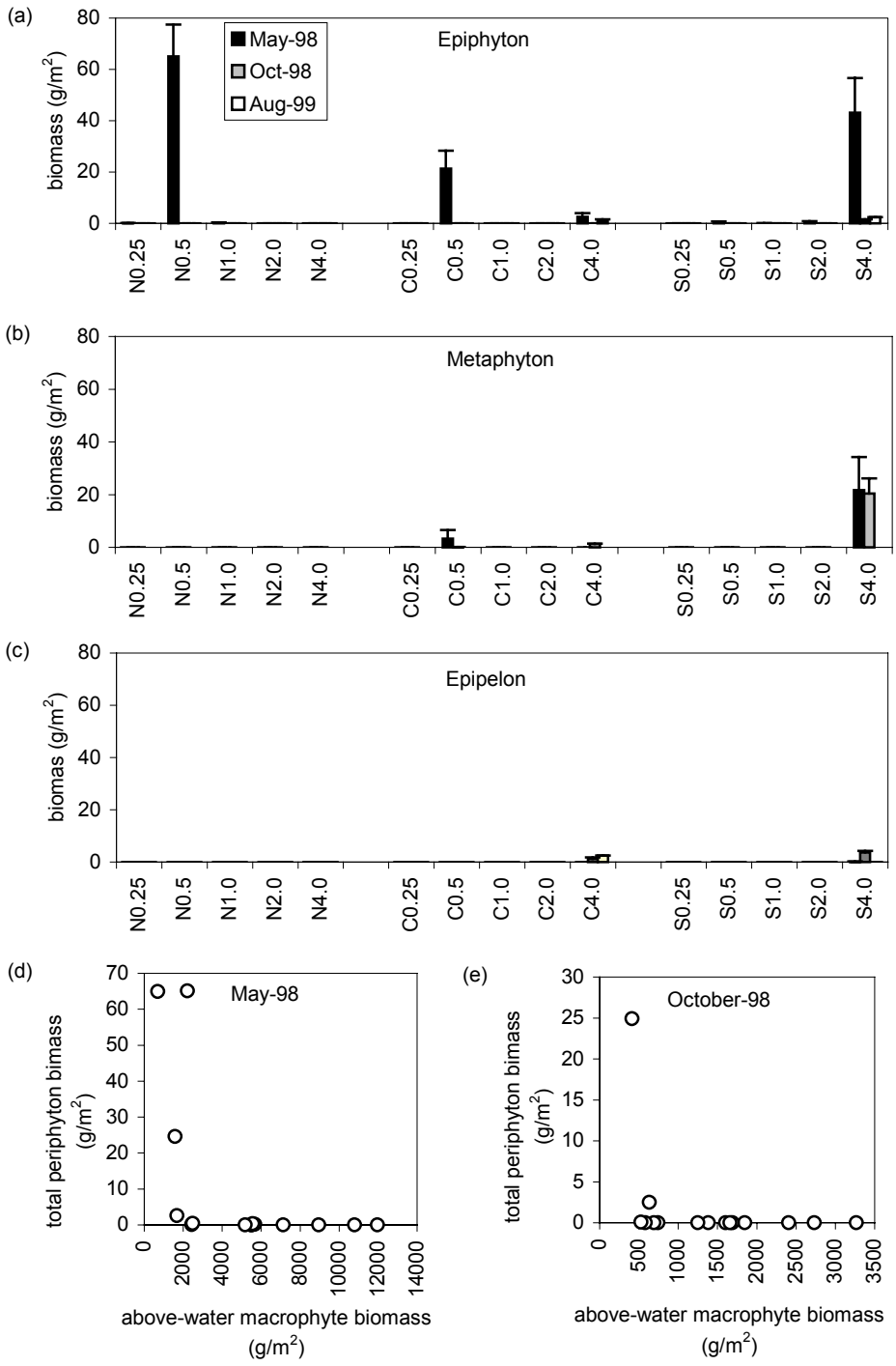

Figure 18. Periphyton biomass by component, station, and date and relationship to above-water macrophyte biomass (bars are means of triplicate samples +1 standard error).

Tissue nutrients

Methods

Approximately 10 g (wet weight) of the dominant periphyton component (generally epiphyton) was collected near the periphyton biomass harvest sites in May 1998 ($N_{0.5}$, $C_{0.5}$, $C_{2.0}$, $C_{4.0}$, $S_{2.0}$, $S_{4.0}$), October 1998 ($C_{0.5}$, $C_{4.0}$, $S_{2.0}$, $S_{4.0}$). Samples were transported back the lab in sealed plastic bags within an ice-filled cooler and immediately shipped to DB labs for analysis of total carbon (TC), total nitrogen (TN), and total phosphorus (TP) concentrations. In October 1998, triplicate samples consisted of such little material that they had to be composited for analysis. Samples also were collected in August 1999, but have not yet been analyzed.

Results

TC and TN exhibited relatively little spatial or temporal variability. TC concentrations ranged between 332,667 ($S_{4.0}$) and 433,000 mg/kg ($C_{2.0}$) in May 1998 and between 393,000 ($C_{4.0}$) and 430,000 mg/kg ($C_{0.5}$) in October 1998 (Figure 19a). TN was within a concentration range of 19,476 ($S_{4.0}$) to 31,400 mg/kg ($S_{2.0}$) in May 1998 and 27,100 ($C_{0.5}$) to 27,900 mg/kg ($S_{2.0}$) in October 1998 (Figure 19b). In contrast, TP exhibited a distinct spatial gradient (Figure 19c). In May 1998, TP concentrations were 1,650 and 1,497 mg/kg, respectively, at the peripheral stations $N_{0.5}$ and $C_{0.5}$. However, TP was to 702 and 380 mg/kg, respectively, at the interior stations $S_{2.0}$ and $S_{4.0}$. In October 1998, TP ranged between 366 mg/kg at $S_{4.0}$ and 2000 mg/kg at $C_{0.5}$.

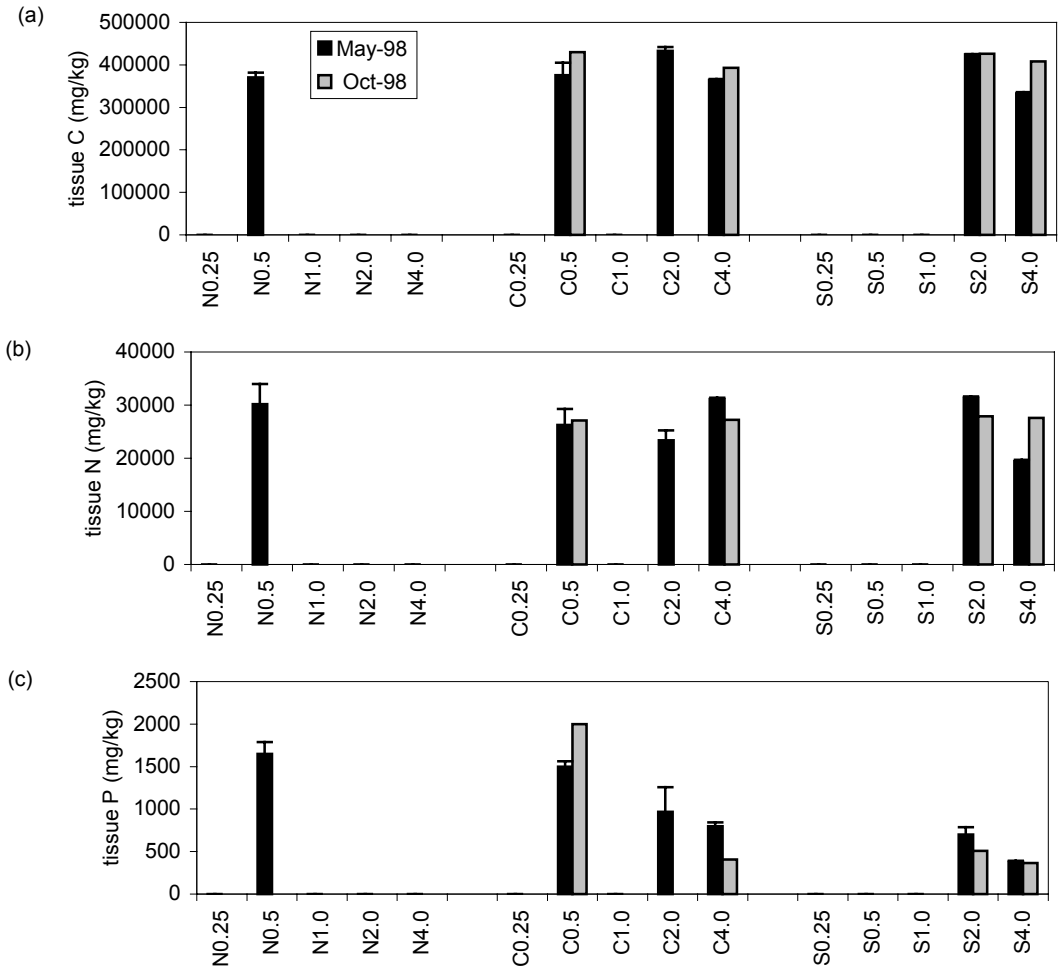

Figure 19. Periphyton tissue carbon (C), nitrogen (N), and phosphorus (P) by station and date (bars are means of triplicate samples +1 standard error).

Primary productivity

Methods

Photosynthesis and respiration rates were measured by light/dark bottle incubations. On May 11, 1998, October 14, 1998, and August 19, 1999, the dominant periphyton component (epiphyton) was collected from an area near the periphyton biomass harvest sites, sealed in plastic bags with a small amount of site water, and transported to the laboratory. Visually similar amounts of each sample were placed in triplicate biological oxygen demand (BOD) bottles filled with surface water collected from the $S_{4.0}$ station. A common source of incubation water was used for practical and logistical reasons since water quality has no significant effect on production rates over the short incubation times (1 to 2 hr) required to obtain these measurements (McCormick, unpublished data).

Each set of BOD bottles was sealed without trapping oxygen bubbles, and half of the bottles were wrapped in aluminum foil to provide darkness for estimates of respiration (no photosynthesis). The remaining bottles were left uncovered to measure net primary production (NPP), which includes both photosynthesis and respiration. Light and dark bottles filled with only water (no periphyton) also were prepared to estimate water-column metabolism. Bottles were incubated outdoors in a large circular tub filled with tap water. The incubation tub was covered with neutral-density shade cloth that reduced irradiance to ~50% in order to mimic field conditions related to macrophyte cover and to prevent photoinhibition. Photon flux was monitored continuously, and incubations were terminated when ~5 mol m^{-2} of photosynthetically active radiation (PAR) had been received. Initial and final dissolved oxygen (DO) concentrations were measured in each bottle using a calibrated, polarographic oxygen probe. Following the incubation, each

sample of periphyton was processed to determine AFDM, and net primary productivity (light bottles) and respiration (dark bottles) were calculated based on rates of change in DO (corrected for water-column metabolism) in relation to the quantity of periphyton (AFDM) and quantity of light received over the incubation period (McCormick et al., 1998).

Results

Among the sites where periphyton samples could be obtained, productivity was generally highest at the peripheral stations of each transect (Figure 20). Net primary productivity (NPP) was highest in October 1998, approaching 14 mg O_2/g AFDM/μmole PAR at station $C_{0.5}$. NPP exceeded 6 mg O_2/g AFDM/μmole PAR at stations $C_{4.0}$, $S_{2.0}$, and $S_{4.0}$ in October 1998 but was less than 4 mg O_2/g AFDM/μmole PAR in August 1999. This temporal variation may reflect hydrologic effects as water levels had been relatively high for approximately 2 months before the October assay. In contrast, severe drought conditions preceded the May 1998 and August 1999 collections.

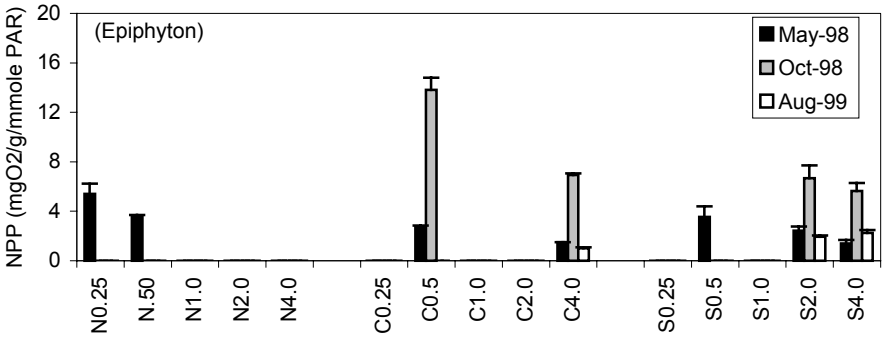

Figure 20. Periphyton net primary productivity (NPP) by station and date (bars are means of triplicate samples +1 standard error).

Taxonomy

Methods

One to two grams (wet weight) of periphyton were separated out from the tissue nutrient samples (collected in May 1998, October 1998, and August 1999) and placed in a centrifuge tube with approximately 10 to 14 ml of deionized water. Samples were preserved in formaldehyde (3.7% v:v) and shipped to FDEP for determinations of species composition and abundance. At the time of this report, however, only grab samples from the May 1998 periphyton biomass harvest had been analyzed.

Results

Lyngbya and *Oscillatoria* were by far the most abundant taxa, but showed no well-defined spatial pattern. Other taxa such as *Anabaena* and *Scenedesmus* that may dominate under nutrient-conditions in other wetlands (Mulligan et al., 1976) were most abundant at NTr stations and absent at STr stations (although very limited in relative numbers). In general, interior STr and CTr stations differed from peripheral and NTr station in terms of overall composition and had a community more indicative of interior, oligotrophic areas of WCA-2A (e.g., *Scytonema*). Additionally, overall species diversity showed a spatial gradient. For example, the mean number of taxa among NTr stations was only 18, whereas among CTr and STr stations this number increased to 23 and 38, respectively. A complete list of taxa is provided in Appendix II.

Periphytometers

Methods

Attempts to deploy periphytometers on a quarterly basis were largely unsuccessful due to frequent periods of insufficient surface water. As a result, only one sampling period from October to December 1998 yielded useable periphytometer data. Periphytometers, each consisting of a rack of 8 glass slides, were placed in the water and tethered to a PVC pole. At the end of the two-month time period, colonized slides were removed from the rack, sealed in a plastic bag, and transported to the laboratory on ice. Periphyton was removed from the slides by razor blade and then homogenized in a known volume of deionized water. Quantitative subsamples were removed for taxonomic analysis, chlorophyll *a*, and biomass estimates.

Chlorophyll *a* samples were preserved with $MgCO_3$ and stored at -4°C until they could be processed (within 30 days). To extract chlorophyll, 9 ml of acetone were added to 1 ml of preserved sample and mixed in a centrifuge tube. The tubes were then sonicated in an ice bath for 60 min. and allowed to steep at 4°C in the dark for 24 hrs. Samples were then allowed to equilibrate to room temperature and centrifuged at 3500 rpm for 12 min. Chlorophyll *a* and phaeopigment concentrations were determined fluorometrically. Ash-free dry mass was determined as described previously. Taxonomic samples were preserved with 3.7% formaldehyde and shipped to FDEP for analysis.

Results

Results

Periphytometer data are limited to one time period (October - December 1998) over which periphyton accumulation could be assessed. Pigment concentrations and biomass were highest on periphytometers from NTr stations (Figure 21a). For example, chlorophyll *a* was 575 and 276 mg/m^2 at $N_{0.25}$ and $N_{1.0}$, respectively, but < 52 mg/m^2 at CTr and STr stations. Biomass ranged from nearly 4 g AFDM/m^2 at $N_{0.25}$ to < 1 g AFDM/m^2 for all other stations except $S_{4.0}$ where periphytometer biomass was 1.7 g AFDM/m^2 (Figure 21b). This spatial variability in biomass accumulation appeared to be a function of both water quality (i.e. phosphorus) and macrophyte cover. Additionally, the amount of chlorophyll per unit biomass was much higher in peripheral NTr compared to CTr and STr samples (Figure 21c), indicating a shift towards a more autotrophic periphyton community at the former sites. Taxonomic data for periphytometers were not available at the time this report was prepared.

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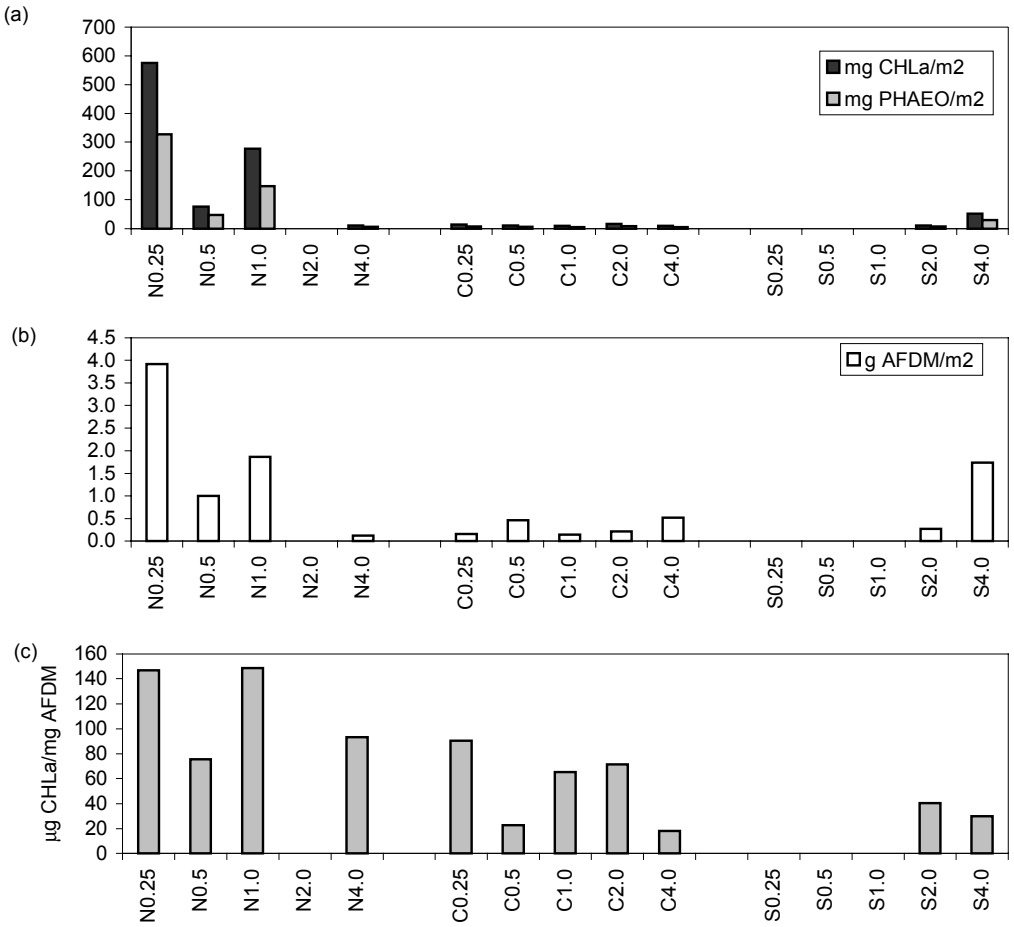

Figure 21. a) Periphyton pigments, b) biomass, and c) chlorophyll a concentration per unit ash-free dry mass by station and date (bars represent data from one periphytometer per station).

Macrophytes

Biomass

Methods

Only the 0.25, 1.0, and 4.0-km stations were sampled along the NTr and STr and no biomass collections were conducted at stations from the CTr. Sampling locations were determined in the same manner as for soil and periphyton sampling within the dominant vegetation type (*Cladium jamaicense* or *Typha domingensis*). All above- and below-ground macrophyte biomass was harvested within three replicate 0.25 m^2 quadrats and transported back to the laboratory in large bags for processing. Plant biomass was then separated into dominant (*Cladium* or *Typha*) and non-dominant species (i.e. species other than *Cladium* or *Typha*). Plant material of the dominant species was further separated into live vs. dead aboveground (shoots/leaves) and belowground (live and dead roots) components. Above- and below-ground material of non-dominant species was combined and processed as a single sample. After processing, the samples were dried at 80°C for two weeks and weighed.

Results

Macrophyte component biomass was highly variable on both a spatial and temporal basis. In March 1998, live leaf biomass ranged between 306 ($S_{0.25}$) and 714 g/m^2 ($N_{4.0}$) for *Cladium* and between 447 ($N_{1.0}$) and 462 g/m^2 ($N_{0.25}$) for *Typha* (Figure 22a). In April 1999, live *Typha* leaves became extremely scarce at $N_{0.25}$ due to the proliferation of white milkweed vine (*Sarcostemma clausum*), which grew over the *Typha* and killed most of the plants. For *Cladium*, live leaf biomass in April 99 was highest at $N_{4.0}$ with a

value of 1,170 g/m^2 and lowest at $S_{4.0}$ with a value of 692 g/m^2. *Cladium* dead biomass in March 1998 varied from a minimum of 1,146 g/m^2 ($S_{4.0}$) to a maximum of 3,365 g/m^2 ($S_{0.25}$) (Figure 22b). In April 1999, minimum and maximum biomass estimates were 1,264 g/m^2 at $S_{1.0}$ and 2,575 g/m^2 at $N_{4.0}$. On both sampling dates, *Cladium* root biomass was highest at $N_{4.0}$ and $S_{0.25}$ (Figure 22c). Furthermore, *Cladium* root biomass for all stations exceeded 1000 g/m^2 in both March 1998 and April 1999. However, *Typha* root biomass was lower than 800 g/m^2 on each sampling date. Total biomass of *Cladium* varied from nearly 8,700 g/m^2 at $N_{4.0}$ in April 1999 to approximately 2,800 g/m^2 at $S_{4.0}$ in March 1998 (Figure 22d). Total *Typha* biomass was low compared to *Cladium* and did not exceed 3,100 g/m^2 for any sampling date. Species other than *Typha* or *Cladium* were only present at $N_{0.25}$ and $N_{1.0}$ (within *Typha*) and at $S_{4.0}$ (within *Cladium*) (Figure 22e). Within the *Typha*-dominated community, the biomass non-*Typha* vegetation (primarily *Sarcostemma clausum*) ranged between 519 and 533 g/m^2 in March 1998 and between 1,713 and 2,712 g/m^2 in April 1999. Within *Cladium* at $S_{4.0}$, non-*Cladium* vegetation (525 g/m^2, primarily *Sagittaria lancifolia*) was found only in May 1998

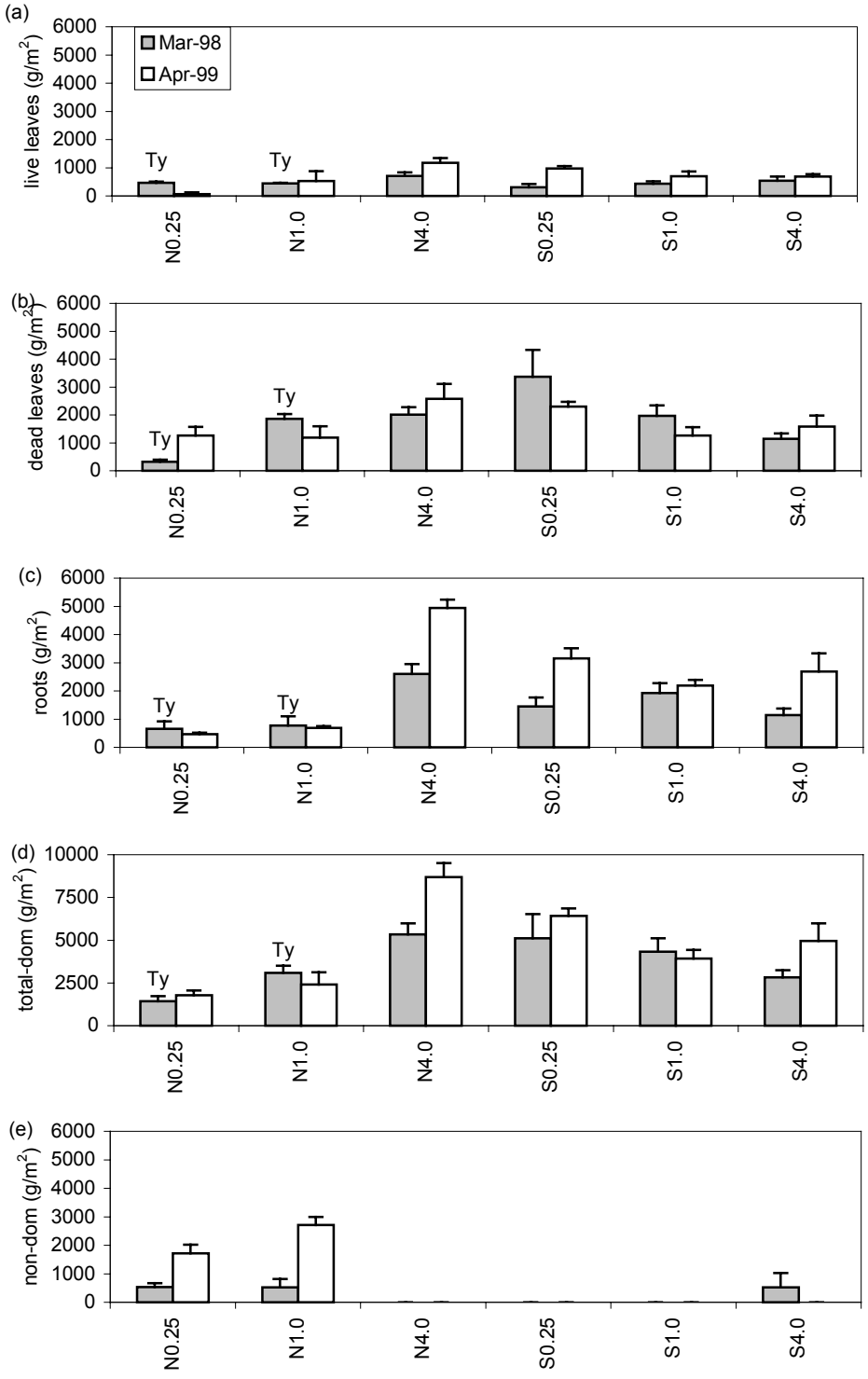

Figure 22. Macrophyte biomass by station and date (Ty = *Typha*-dominated; no symbol = *Cladium*-dominated; non-dom = non-*Typha*/*Cladium*; bars are means of triplicate samples +1 standard error).

Plant/leaf densities and heights

Methods

Permanent 0.25 m^2 plots were established at the 0.25, 1.0, and 4.0-km stations along each transect approximately 5 m to the north, east or west, and south of the reference poles used for biomass collections within the *Cladium* and *Typha* communities. Two opposite corners of each plot were demarcated with lengths of conduit around which a 0.25 m^2 quadrat could be fit during analysis. The number of plants of each individual species within the plots was counted in August of 1998 and 1999. Plants were identified according to Godfrey and Wooten (1979), Bell and Taylor (1982), and Tobe (1998). For the dominant species (*Cladium* and *Typha*) numbers of both live and dead standing leaves were recorded. In addition, the heights of 10 randomly selected leaves of the dominant vegetation (*Cladium* or *Typha*) were recorded in these same plots. If less than 10 leaves were present within the plot, additional leaves adjacent to the plot were used.

Results

The number of *Typha* plants at $N_{.25}$ and $N_{1.0}$ was < 15 plants/m^2 (Figure 23a). *Cladium* plant densities were much higher and variable among stations, ranging between 16 and 53 plants/m^2. There were also significantly fewer plants at stations $S_{0.25}$ and $S_{1.0}$ in 1999 compared to 1998. At all other stations, *Cladium* plant densities were similar between the two sampling dates. Number of live leaves essentially mirrored that of whole plant densities and for *Cladium* ranged between 110 and 270/m^2 in 1998 and between 89 and 265/m^2 in 1999 (Figure 23b,c). In 1999, NTr and CTr dead leaf densities were much reduced since the area was recovering from a fire that occurred in June 1999.

Among the unburned STr stations, however, standing live and dead leaf numbers were similar to those recorded in 1998. In August 1998, total *Cladium* leaf densities varied from a maximum of 589 leaves/m^2 at $N_{4.0}$ to a minimum of 325 leaves/m^2 at $C_{4.0}$ (Figure 23d). Non-dominant plants occurred only at $N_{0.25}$, $N_{1.0}$, $C_{4.0}$, and $S_{1.0}$. Plant densities of these species were high compared to *Cladium* and *Typha* (Figure 24a). However, most of these plants were very small in stature (i.e. *Rynchospora*, *Cyperus*, *Polygonum*, *Proserpinica* spp.) and contributed little to overall biomass and vegetative cover. Additionally, some of these species are ephemeral, appearing for only short periods of time when hydrology and other environmental conditions become favorable. Total number of species per plot did not exceed 4, and species diversity did not show any obvious spatial pattern (Figure 24b). In this regard, monospecific *Cladium* or *Typha* communities were the most common community type.

In 1998, mean leaf heights for *Cladium* ranged between 141.7 ($C_{4.0}$) and 197.9 cm ($C_{0.25}$) whereas *Typha* leaf heights were > 200 cm (Figure 24c). In 1999, after the NTr and CTr had been burned, *Cladium* leaf heights ranged between 99.5 ($C_{4.0}$, burned) and 177.5 cm ($S_{4.0}$, unburned). *Typha* leaf height averaged 239.5 cm at $N_{1.0}$ in 1999 but was absent from the plots at $N_{0.25}$ due to invasion by *S. clausum*.

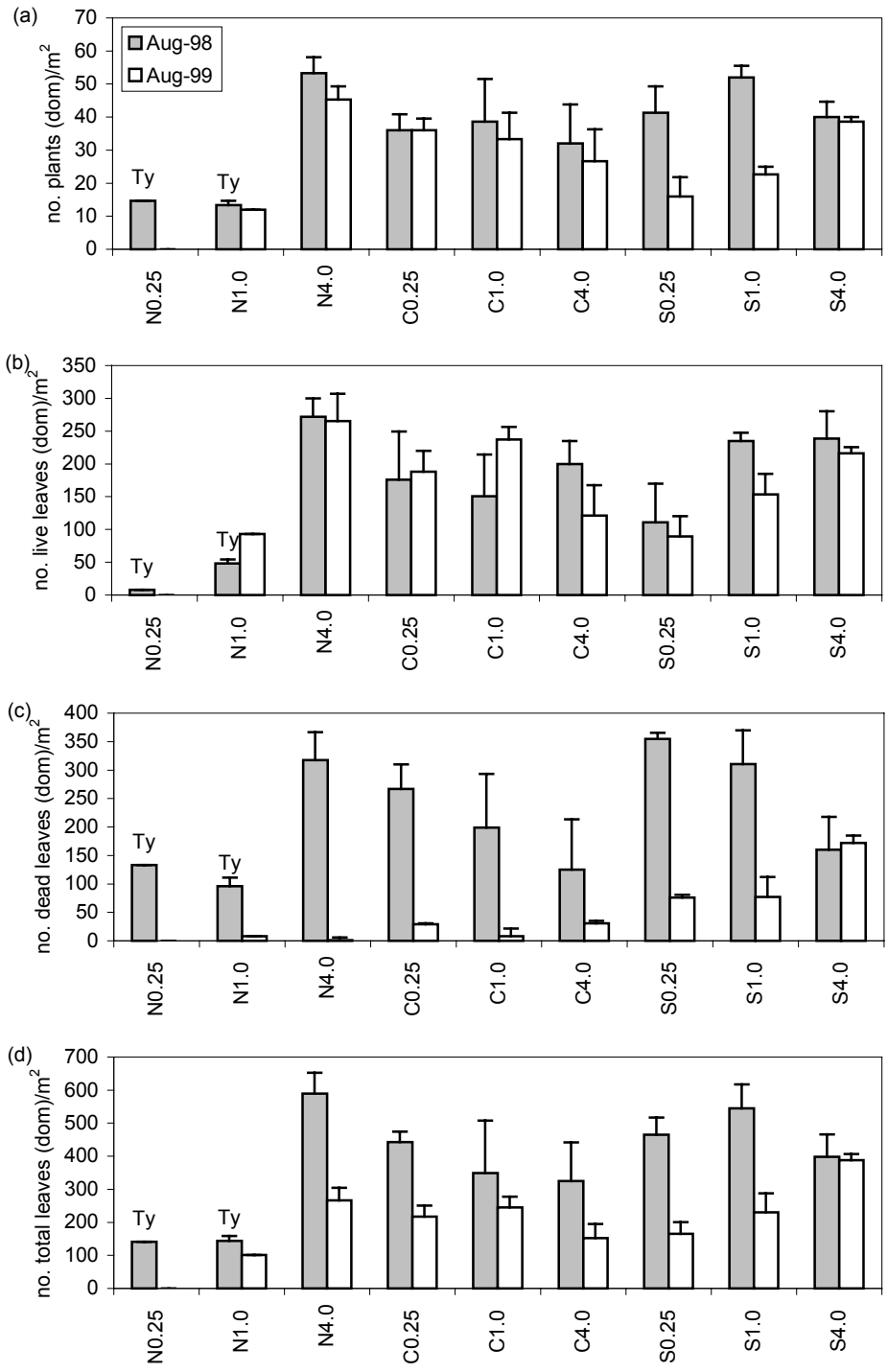

Figure 23. Plant and leaf densities of dominant species (Ty = *Typha*-dominated; no symbol = *Cladium*-dominated; bars are means of triplicate samples +1 standard error).

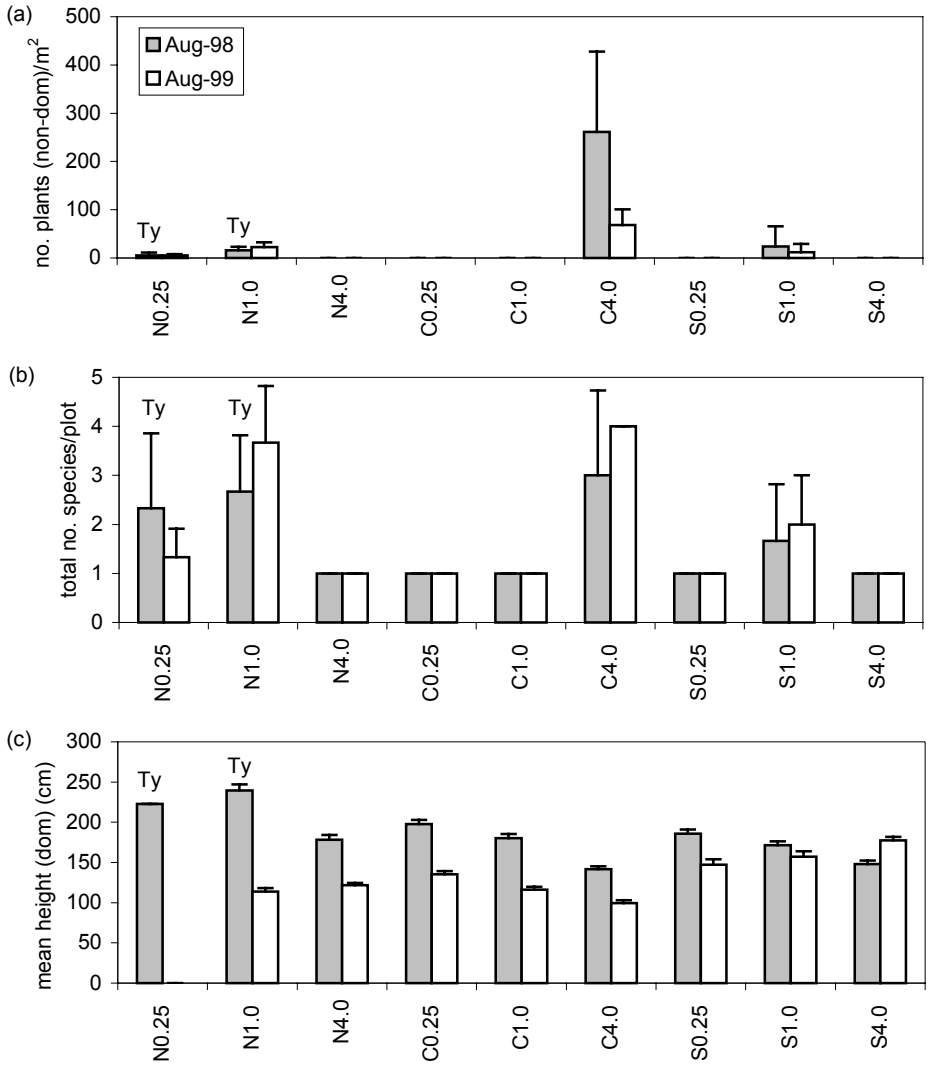

Figure 24. Plant densities of non-dominant species by station and date (Ty = *Typha*-dominated; no symbol = *Cladium*-dominated; bars are means of triplicate samples +1 standard error).

Tissue nutrients

Methods

Samples (3 to 4 grams dry weight) of live leaves, dead leaves, roots, and other (collected during the biomass harvest), dried, and shipped to DB labs for analysis of TN and TP.

Results

TN was higher in the live and dead leaves of *Typha* compared to *Cladium* (Figures 25a,b). On both sampling dates *Typha* live leaf TN exceeded 8,900 mg/kg while *Cladium* leaf TN always was lower than this value. Dead leaf TN exhibited a more pronounced difference between *Typha* and *Cladium* in 1999 than in 1998. Root TN was highest in *Typha* at station $N_{0.25}$ and varied from 21,533 mg/kg in 1998 to 16,233 mg/kg in 1999 at this station (Figure 25c). *Typha* root TN from station $N_{1.0}$ was similar to *Cladium* root TN from the rest of the stations, which ranged between 5,377 ($S_{0.25}$) and 12,177 mg/kg ($S_{1.0}$) in 1998 and between 6,044 ($S_{1.0}$) and 11453 mg/kg ($S_{4.0}$) in 1999. Composite samples of leaves and roots from non-dominant plants contained highly variable concentrations of TN (Figure 25d), ranging between 7,685 ($N_{1.0}$, 1999) and 21,000 mg/kg ($S_{4.0}$, 1998).

TP was significantly higher in the live leaves and roots of *Typha* than *Cladium* (Figure 26a). On both sampling dates, live *Typha* leaf tissue contained > 800 mg/kg TP whereas live *Cladium* leaves had < 400 mg/kg TP. Dead leaf tissue TP was much lower for both species, but was higher in *Typha* (> 250 mg/kg, both sampling dates) than *Cladium* (< 250 mg/kg, both sampling dates) (Figure 26b). In live leaves and roots of

Cladium, tissue P was higher at in March 1998 than April 1999 while dead leaves did not exhibited this trend. In 1998, *Typha* roots at station $N_{0.25}$ had the highest TP concentration (3,110 mg/kg) of all species and biomass components (Figure 26c). *Cladium* root TP concentrations were generally ten-fold lower than this value, ranging between 111 ($S_{4.0}$) and 253 mg/kg ($N_{4.0}$) in 1998 and between 166 ($S_{1.0}$) and 326 mg/kg ($S_{4.0}$) in 1999. Other vegetation (mainly *S. clausum*) had TP concentrations ranging between 758 ($N_{1.0}$) and 1,973 mg/kg ($N_{0.25}$) across both sampling dates (Figure 26d).

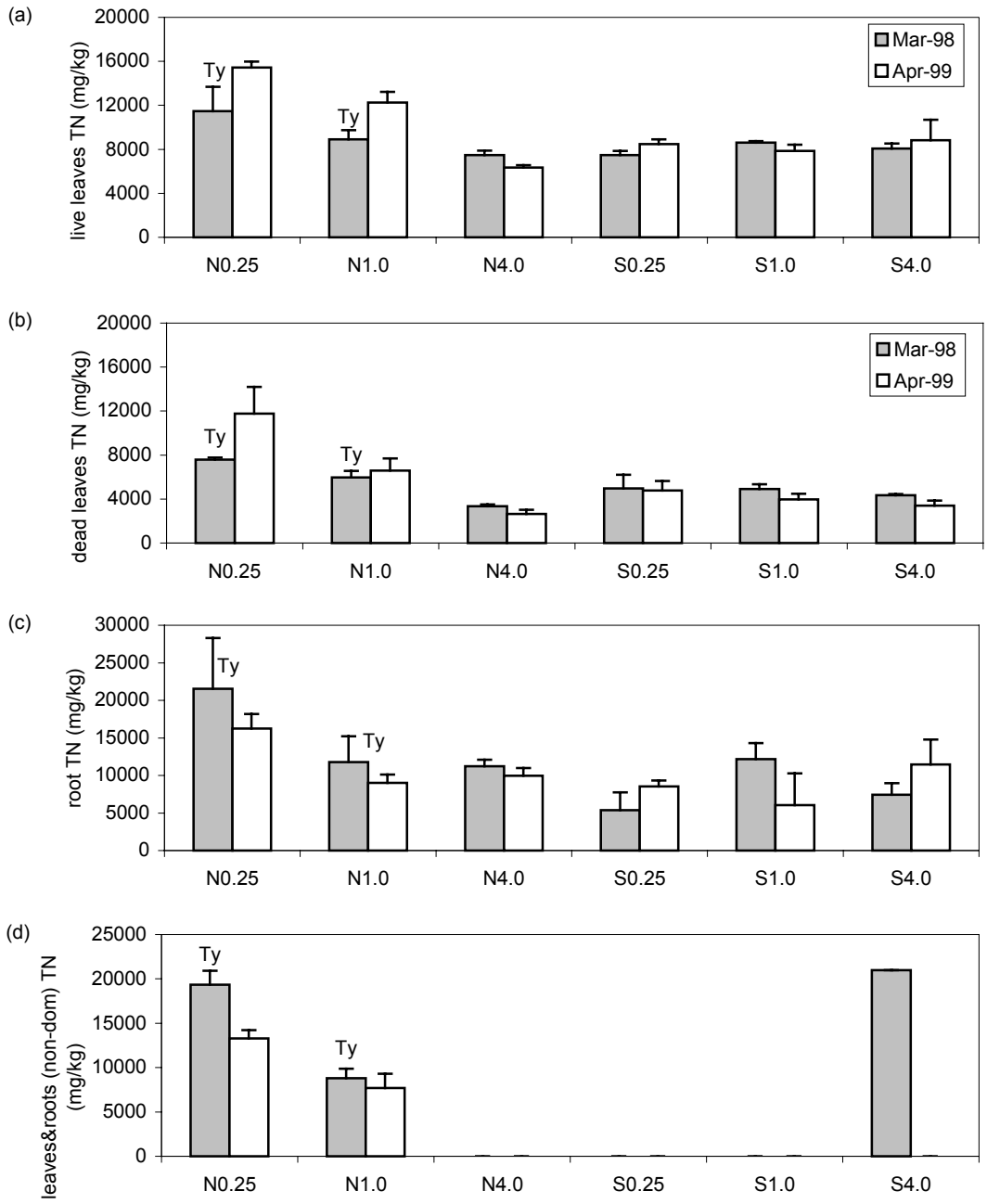

Figure 25. Plant tissue nitrogen (TN) by station and date (Ty = *Typha*; no symbol = *Cladium*; bars are means of triplicate samples +1 standard error).

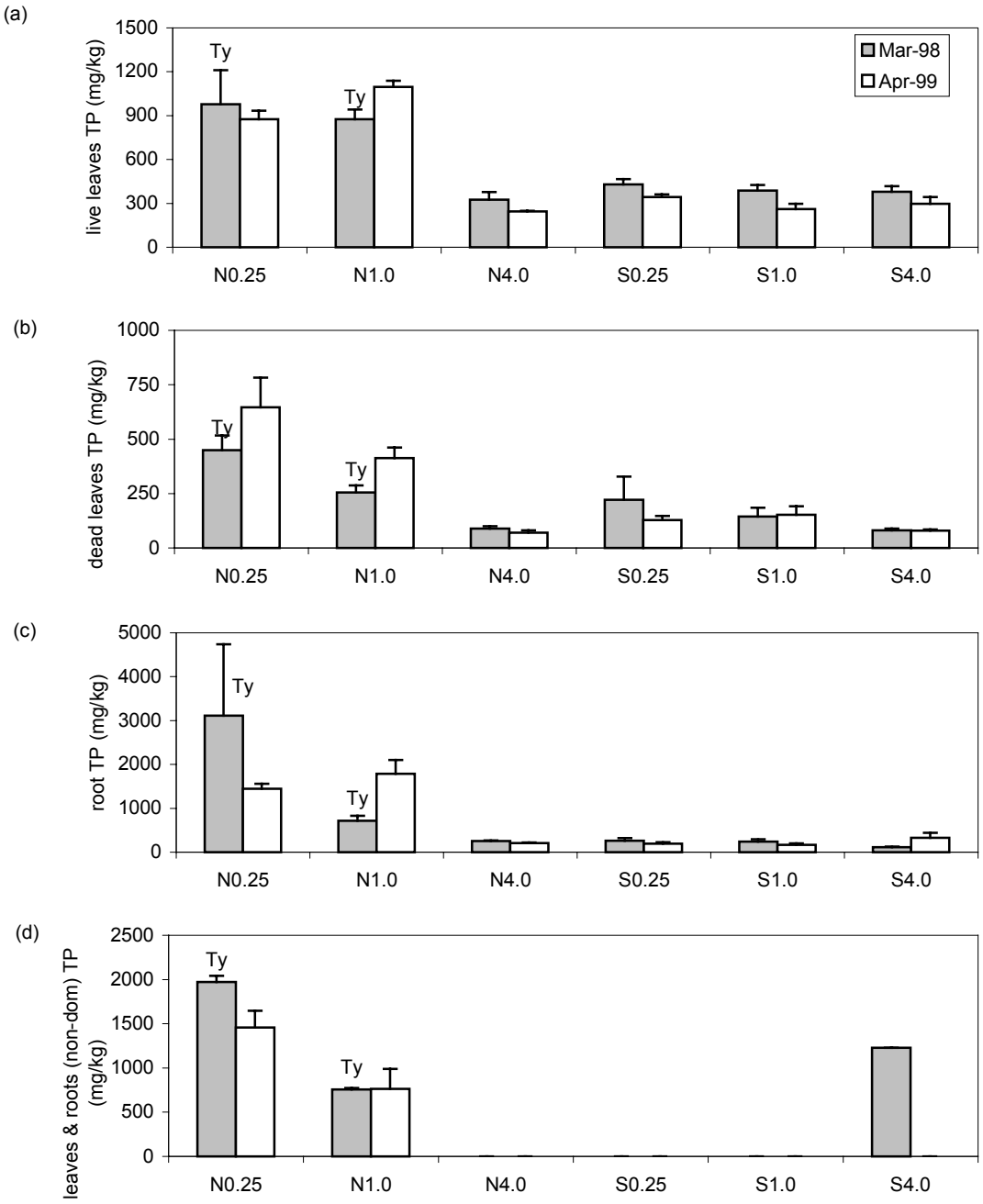

Figure 26. Plant tissue phosphorus (TP) by station and date (Ty = *Typha*; no symbol = *Cladium*; bars are means of triplicate samples +1 standard error).

General species diversity

Methods

A list of all submerged and emergent plant species occurring within ~10 m of the station platforms was compiled by visual inspection during 1998 and 1999 (March to November). The most recent list of species (1999) for each station is provided in Appendix III.

Results

In general, all monitoring stations are located within areas dominated by either *Typha* ($N_{0.25}$, $N_{0.5}$, and $N_{1.0}$) or *Cladium* (all other stations). Overall species diversity was fairly low, with no more than ten different species per station occurring in either 1998 or 1999 (Figure 27a). The number of new species appearing in 1999 reached a maximum at station $N_{2.0}$. Many other stations had 1 to 3 new species recorded in 1999 (Figure 27b). Conversely, up to 8 species disappeared by 1999 at station $C_{4.0}$ (Figure 27c). Net increases in the total number of species were observed at $N_{2.0}$, $C_{0.25}$, $C_{1.0}$, C_{20}, and $S_{4.0}$ (Figure 27d). Reductions were observed in the cattail zone and at most STr stations. It is important to note, however, that changes largely involve only non-dominant species and, with the exception of *S. clausum* proliferation at $N_{0.25}$, there was no significant alteration in the vegetational landscape surrounding the monitoring stations.

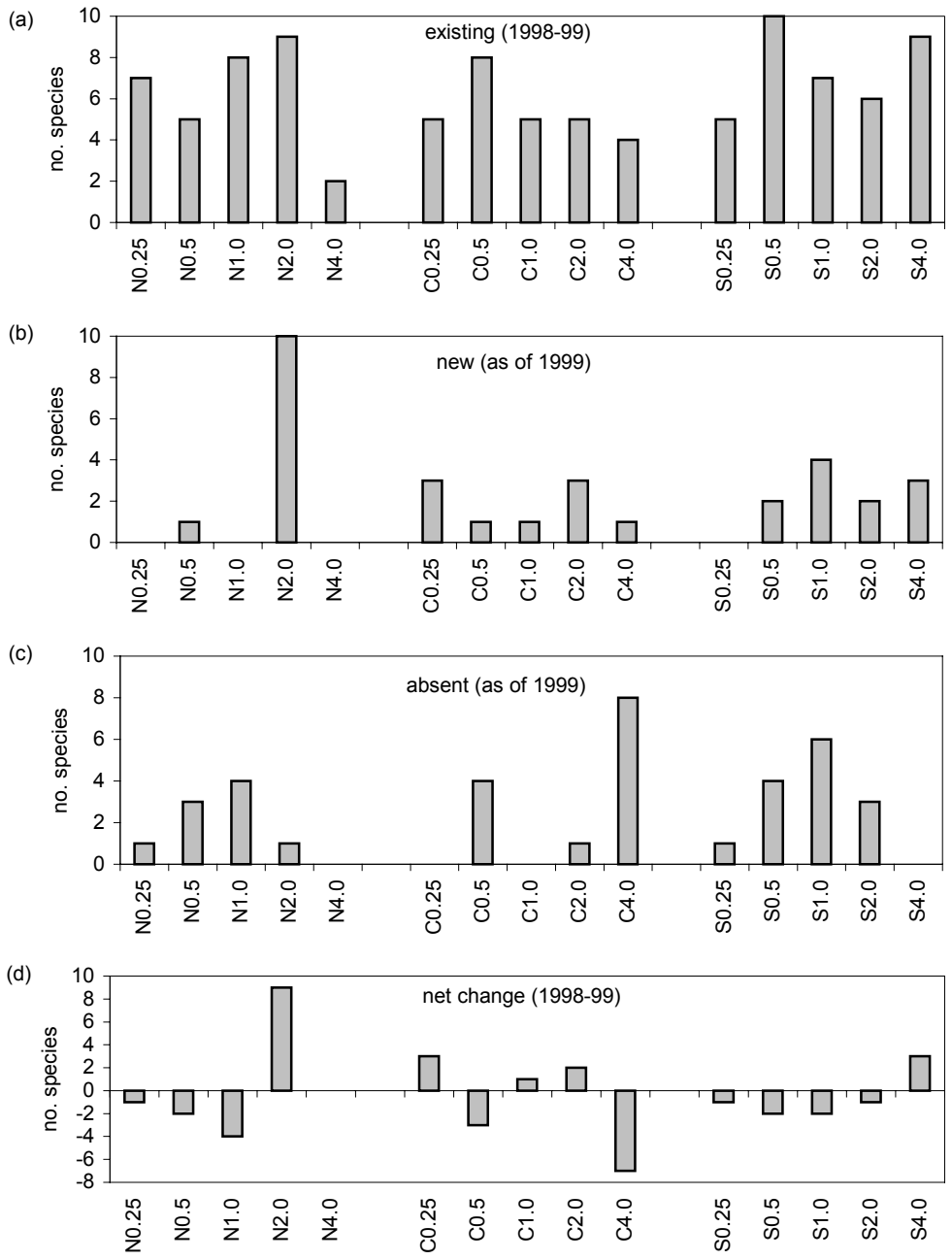

Figure 27. Numbers of existing, new, and absent macrophyte species from 1998-1999 by station.

Everglades Phosphorus Gradient Model

According to Special Condition 1.b.(3) of the Section 404 Dredge and Fill Permit No. 199404532, by January 1, 2000, the District is required to submit to the U. S. Army Corps of Engineers, the USEPA, and the FDEP, the recalibrated Everglades Phosphorus Gradient Model (EPGM) to predict the effects of the hydropattern restoration features of STA-2 on downstream receiving waters. As described in the Hydropattern Restoration Plan submitted by the District to the U.S. Army Corps of Engineers on August 1, 1997, the District collected baseline information on surface water and soil nutrients for use in recalibration of the EPGM.

The EPGM (also used in the 1996 Programmatic Environmental Impact Statement (PEIS) evaluation) simulates increases in soil and water-column P concentrations along a horizontal gradient imposed by an external P load and sheet-flow conditions. Potential biological responses are expressed in terms of marsh surface areas exceeding threshold criteria for water-column and soil P concentrations. Areas exceeding water-column P threshold criteria (0.010 to 0.030 mg/L) are surrogates for impacts on ecosystem components that respond primarily to variations in water-column concentration (e.g., periphyton). Areas exceeding soil P threshold criteria (540 to 990 mg/kg) are surrogates for impacts on ecosystem components that respond primarily to variations in soil P (e.g., cattails and other rooted vegetation). The model is thought to generate conservative estimates of soil and cattail response, mainly because a portion of the P removed from the water-column will not reach the soil, but will be stored as increased plant biomass (Walker and Kadlec, 1996).

Due to the short period of monitoring (during which no vegetative or soil chemistry changes have occurred), recalibration of the model is not currently possible using the available data. In lieu of recalibrating the model, revised simulations were performed using the 2-year geometric mean of the 404-Permit monitoring data for soil bulk density and total P content that was collected.

For the revised simulations, the 0.050 mg/L TP discharge period was changed from 8 years, the period used in the 1996 PEIS, to 7 years to reflect the current construction schedule. It should be noted that the revised simulation results are generally more conservative because the actual 0.050 mg/L discharge period will be closer to 6.25 years.

The average annual STA outflow volumes used in the revised simulation was 205.1 KAF (includes Best Management Practices make-up water). This outflow volume is nearly identical to that used in the 1996 PEIS (205.8 KAF).

Similar to the 1996 PEIS evaluation, simulations were performed using TP and bulk density data from the 0-20 cm soil depth interval, which is considered to be more accurate than 0-10 cm (Walker and Kadlec, 1996). A summary of the revised EPGM simulation is presented in Table 3.

For the 205.1 KAF - 20 cm soil depth scenario, the estimated area exceeding the10 ppb water column threshold was 5506 ha or 30% of the total area. The estimated area of potential cattail expansion was 103 ha. or 0.5 % of the total area.

Table 3. Summary of Everglades Phosphorus Gradient Model simulation results.

Summary

From the spatial variability in concentrations of surface water constituents, it appears that peripheral NTr and, to a lesser extent, CTr stations are influenced by canal discharge from the S-10E water control structure (see location in Figure 1). The topography of this area is such that a large portion of S-10E discharge flows almost directly west and then southwest along the L-6 levee (Fitz and Sklar, 1999). Consequently, a gradient of many water and soil elements (particularly P) has developed in a north - south, peripheral - interior (i.e., northwest to southeast) direction. Some deviations from this gradient occur along the CTr and STr where a number of surface-water constituents increase towards the interior stations. The reason for this is undetermined, but it is possible that these stations are influenced by S-7 discharge. Regardless, the main gradient also is evident in porewater and soil chemistry. With a few exceptions, the water quality of this area is similar to that which has been observed along a north-south eutrophication gradient in northeastern WCA-2A (McCormick 1996; McCormick and O'Dell, 1996). Soil properties are also similar in that a well-defined TP gradient exists, although concentrations at peripheral NTr stations are lower than those of enriched areas in northeastern WCA2A (Reddy et al., 1998).

The biotic components of this region appear to have responded both quantitatively and qualitatively to these physical environmental conditions. For example, periphyton communities undergo a distinct shift in character from peripheral NTr stations to interior CTr and STr stations. Specifically, a community that is rich in chlorophyll *a* and does not form cohesive mats dominates at peripheral NTr stations. This is replaced by calcareous mat communities at interior STr stations and corresponds with a significant

decline in periphyton tissue P content and NPP. These spatial patterns are similar to those described by McCormick et al. (1998) for northeastern WCA-2A. In general, however, periphyton is an inconspicuous component of the ecosystem in this region, its development presumably being inhibited by inadequate light availability (due to high levels of macrophyte biomass) (Grimshaw et al., 1993) in addition to the relatively short hydroperiod for this portion of the marsh.

Macrophyte communities also exhibit a distinct shift as *Typha*-dominated peripheral NTr stations change to dense *Cladium* at peripheral CTr and STr stations. In structure, these communities resemble *Typha* and *Cladium* communities found in eutrophic areas of northeastern WCA-2A (Miao and Sklar, 1998). Towards the interior stations of the CTr and STr, dense *Cladium* gives way to sparse *Cladium*, interspersed occasionally with wet prairie (primarily *Eleocharis and Rynchospora*) habitat. Tissue P content of the dominant vegetation decreases significantly in this direction as well. At the $C_{4.0}$ and $S_{4.0}$ stations, macrophyte communities bear more likeness to oligotrophic areas of interior WCA-2A.

Overall, the area encompassed within the monitoring boundary reflects the impacts of canal inflow and the attenuation of these impacts over distance. Further strengthening, dissipation, or maintenance of this gradient will depend on the water quality, volume, and outflow locations of STA-2 discharge.

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Appendix I. Schematic representation of sampling from and near the station platforms.

Appendix II. Periphyton taxonomy, cell densities by station for May 1998 grab samples.

Station	Taxon	Cell count
$N_{0.25}$		
	Anabaena	34
	Chroococcus	6
	Cyclotella	1
	Eunotia	1
	Eunotia flexuosa	1
	Gomphonema	1
	Gomphonema gracile	1
	Lagynion	2
	Lyngbya	478
	Navicula confervacea	2
	Nitzschia	2
	Nitzschia amphibia	1
	Nitzschia amphibia frauenfeldii	1
	Oedogonium	9
	Oscillatoria	247
	Pennales	2
	Rhopalodia gibba	12
	Synechococcus	10
$N_{0.5}$		
	Anabaena	6
	Ankistrodesmus	1
	Aphanocapsa	7
	Chlorella	1
	Chroococcus	1
	Lyngbya	300
	Navicula cryptocephala	2
	Nitzschia	2
	Oedogonium	4
	Oscillatoria	186
	Scenedesmus obliquus	4
	Schizothrix	18
	Synechococcus	4
$N_{1.0}$		
	Anabaena	95
	Aphanocapsa	6
	Chlorella	2
	Chroococcus	2
	Diatomaceae	1

Eunotia	1
Eunotia flexuosa	1
Gomphonema	1
Lyngbya	507
Navicula	1
Navicula cryptocephala	3
Navicula minima	1
Nitzschia	13
Nitzschia amphibia	1
Nitzschia amphibia frauenfeldii	3
Nitzschia palea	2
Oocystis	1
Oscillatoria	170
Rhopalodia gibba	11
Scenedesmus bijuga	2
Spirulina	3
Synechococcus	8
Synedra ulna	1

$C_{0.5}$

Anabaena	4
Ankistrodesmus	1
Aphanocapsa	3
Chlorella	1
Chroococcus	11
Lyngbya	130
Mougeotia	1
Nitzschia	3
Oedogonium	6
Oscillatoria	121
Oscillatoria acutissima	30
Rhopalodia gibba	6
Scenedesmus bijuga	2

$C_{2.0}$

Achnanthes	1
Achnanthes minutissima	2
Lyngbya	48
Mougeotia	63
Nitzschia	1
Oedogonium	18
Oscillatoria	39
Spirogyra	8
Synedra ulna	1
Synedra radians	2
Synedra delicatissima	1

	Zygnema	30
$C_{4.0}$		
	Achnanthes	1
	Anabaena	243
	Anomoeneis vitrea	1
	Aphanocapsa	2
	Chroococcus	4
	Cosmarium	1
	Cymbella	4
	Cymbella muelleri	1
	Cymbella pusilla	1
	Cymbella lunata	1
	Cymbellaceae	4
	Diatomaceae	17
	Diploneis	1
	Diploneis ovalis	1
	Diploneis oblongella	1
	Eunotia	1
	Fragilaria synegrotesca	6
	Gomphonema	1
	Gomphonema gracile	1
	Gomphonema intricatum vibrio	1
	Gomphosphaeria	16
	Lyngbya	64
	Mastogloia	11
	Mastogloia smithii	13
	Navicula	2
	Navicula pupula	1
	Navicula radiosa	1
	Navicula radiosa tenella	5
	Navicula viridula	16
	Nitzschia	8
	Nitzschia obtusa	1
	Nitzschia amphibia	1
	Nitzschia palea	6
	Nitzschia denticula	1
	Nitzschia paleaformis	1
	Nitzschia amphibioides	2
	Oscillatoria	178
	Oscillatoria splendida	27
	Pennales	3
	Pinnularia	1
	Rhopalodia gibba	3
	Spirulina	531
	Synechococcus	6

$S_{0.5}$

Achnanthes	1
Anabaena	35
Anomoeneis vitrea	1
Chlorella	1
Chroococcus	4
Cylindrospermum	22
Cymbella	1
Cymbella microcephala	3
Diatomaceae	8
Fragilaria synegrotesca	2
Gloeothece	4
Gomphonema gracile	1
Lyngbya	112
Mastogloia	1
Mastogloia smithii	2
Mougeotia	36
Navicula	2
Navicula radiosa	1
Nitzschia	2
Nitzschia amphibioides	1
Oedogonium	4
Oscillatoria	75
Pennales	4
Scytonema	96
Spirulina subsalsa	12

$S_{2.0}$

Achnanthes	3
Achnanthes minutissima	2
Anabaena	33
Anomoeneis vitrea	2
Chlorella	3
Chlorococcum	1
Chroococcus	7
Cymbella microcephala	2
Diatomaceae	12
Fragilaria	1
Fragilaria synegrotesca	2
Gomphonema intricatum vibrio	1
Lagynion	1
Lyngbya	360
Mastogloia	6
Mastogloia smithii	4
Merismopedia punctata	30

Mougeotia	2
Navicula radiosa tenella	2
Navicula viridula	4
Nitzschia	4
Nitzschia palea	1
Nitzschia amphibioides	2
Oedogonium	8
Oocystis	1
Oscillatoria	118
Pennales	3
Pleurotaenium	1
Scytonema	148
Spirulina	4
Stauroneis anceps	2

$S_{4.0}$

Achnanthes	1
Anabaena	112
Ankistrodesmus	1
Chlorella	2
Cosmarium	1
Cymbella	2
Cymbella muelleri	1
Cymbella lunata	4
Cymbellaceae	2
Diatomaceae	4
Fragilaria synegrotesca	1
Gloeothece	8
Gomphonema	1
Lyngbya	319
Mastogloia	24
Mastogloia smithii	22
Navicula	1
Navicula cryptocephala	1
Navicula radiosa \ tenella	1
Navicula viridula	1
Nitzschia	1
Nitzschia obtusa	1
Nitzschia palea	1
Nitzschia denticula	1
Nitzschia paleaformis	1
Nitzschia amphibioides	2
Oedogonium	5
Oocystis	1
Oscillatoria	610
Pennales	1

Rhopalodia gibba	1
Scytonema	106
Spirulina	295
Stauroneis	1
Synechococcus	17

Appendix III. Macrophyte species currently present (1999) by sampling station.

$N_{0.25}$

Alternanthera philoxeroides
Amaranthus australis
Polygonum hydropiperoides
Sacciolepis striata
Sagittaria spp.
Sarcostemma clausum
Typha domingensis

$N_{0.5}$

Amaranthus australis
Cladium jamaicense
Polygonum hydropiperoides
Sagittaria latifolia
Sarcostemma clausum
Typha domingensis

$N_{1.0}$

Amaranthus australis
Cladium jamaicense
Ludwigia repens
Ludwigia spp.
Polygonum hydropoperiodes
Sagittaria latifolia
Typha domingensis

$N_{2.0}$

Ammannia spp.
Bacopa caroliniana
Blechnum surrulatum
Boehmeria cylindrica
Cladium jamaicense
Conoclinum coelestinum
Cyperus haspan
Kosteletzkya virginica
Ludwigia repens
Ludwigia spp.
Mikania scandens
Peltandra virginica
Pluchea odorata
Polygonum hydropiperoides
Pontederia cordata
Proserpinaca palustris
Sagittaria latifolia

Sarcostemma clausum

$N_{4.0}$

Cladium jamaicense
Sagittaria latifolia

$C_{0.25}$

Cladium jamaicense
Ludwigia repens
Mikania scandens
Panicum hemitomon
Peltandra virginica
Pluchaea spp.
Polygonum hydropiperiodes
Sagitaria latifolia

$C_{0.5}$

Blechnum serrulatum
Cladium jamaicense
Mikania scandens
Myrica cericera
Polygonum hydropiperoides
Proserpinaca paulustris
Sagittaria latifolia
Sarcostemma clausum
Typha domingensis

$C_{1.0}$

Blechnum serrulatum
Cladium jamaicense
Mikania scandens
Peltandra virginica
Polygonum hydropiperoides
Thelypteris paulustrus

$C_{2.0}$

Alternanthera philoxeroides
Blechnum serrulatum
Boehmeria cylindrica
Cladium jamaicense
Mikania scandens
Peltandra virginica
Pluchaea spp.
Sagittaria latifolia

$C_{4.0}$

Blechnum serrulatum
Cephalanthus occidentalis
Cladium jamaicense
Pluchea odorata
Sagittaria latifolia

$S_{0.25}$

Blechnum serrulatum
Cladium jamaicense
Mikania scandens
Peltandra virginica
Sagittaria latifolia

$S_{0.5}$

Andropogon glomeratus
Blechnum serrulatum
Boehmeria cylindrica
Cladium jamaicense
Magnolia virginiana
Mikania scandens
Myrica cerifera
Pontederia cordata
Proserpinaca paulustris
Ryncospora divergens
Sacciolepis striata
Sagittaria latifolia

$S_{1.0}$

Andropogon glomeratus
Blechnum serrulatum
Boehmeria cylindrica
Cladium jamaicense
Mikania scandens
Myrica cerifera
Peltandra virginica
Pluchea odorata
Polygonum hydropiperoides
Proserpinaca paulustris
Xyris spp.

$S_{2.0}$

Blechnum serrulatum
Cladium jamaicense
Mikania scandens
Myrica cerifera

Pontederia cordata
Proserpinaca paulustris
Sagittaria latifolia
Sarcostemma clausum

$S_{4.0}$

Cladium jamaicense
Cyperus spp.
Dichromena colorata
Eleocharis cellulosa
Eleocharis elongata
Nymphaea odorata
Panicum hemitomon
Ryncospora corniculata
Ryncospora inundata
Ryncospora tracyii
Sagittaria latifolia
Sarcostemma clausum